DOCUMENT RESUME

ED 110 011 IR 002 279

AUTHOR	Amara, Roy
TITLE	Toward Understanding the Social Impact of Computers. IFF Report R-29.
INSTITUTION	Institute for the Future, Menlo Park, Calif.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	May 74
NOTE	141p.
AVAILABLE FROM	Institute for the Future, 2740 Sand Hill Road, Menlo Park, California 94025 ($10.00)
EDRS PRICE	MF-$0.76 PLUS POSTAGE. HC Not Available from EDRS.
DESCRIPTORS	Adult Education; *Attitudes; Computer Programs; *Computers; Computer Science Education; Conference Reports; Decision Making; Electronic Data Processing; Financial Policy; *Futures (of Society); Public Opinion; Scientific Literacy; Simulation; Social Attitudes; *Social Change; Technological Advancement; *Values
IDENTIFIERS	Computer Literacy; IFF; *Institute For The Future

ABSTRACT

Summaries of four workshops sponsored by the Institute For The Future (IFF) are presented. Each focuses on a particular aspect of the social impact of computers: (1) computer models and simulations as aids to decision making; (2) the use of computers in financial operations; (3) perceptions, attitudes, and literacy regarding computers (i.e., knowledge about the capabilities and limitations of computers in meeting human needs); and (4) individual access to computers. Workshop participants and the IFF staff conclude that there is a need for the public to acquire a deeper understanding of how computers affect the decisions individuals and organizations make, the goods and services they produce, and the world that individuals perceive. It is also concluded that such improved understanding must be acquired in the near future. A program of education for the public is then proposed. (Author/DGC)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED110011

TOWARD UNDERSTANDING THE SOCIAL IMPACT OF COMPUTERS

Roy Amara

Supported by
National Science Foundation
Grant Number GJ-37008

Institute for the Future
2740 Sand Hill Road
Menlo Park, California 94025

May 1974

Report R-29

IR002279

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL BY MICROFICHE ONLY HAS BEEN GRANTED BY
Institute for the Future
TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER."

The Institute for the Future is an independent research organization, founded as a nonprofit corporation for work solely in the public interest. It is dedicated exclusively to systematic and comprehensive study of the long-range future. The Institute's primary aims, as formulated in its Articles of Incorporation, are fourfold:

". . . to enlarge existing understanding concerning technological, environmental, and societal changes and their long-range consequences; to develop new methodology to carry on such tasks; to make available without discrimination the results of such research and scientific advances to the public; and to serve as an educational and training center for selected persons from business, government, foundations, and universities with respect to such research activities."

The Institute's research program has two major components: development of forecasting methods for the analysis and synthesis of potential futures, and the application of such methods to the problems of society. Among the general areas of this research are the future state of the Union; the influence of future technological developments on societal trends; social indicators and the quality of life; and long-range urban and national planning. More specific topics have also been examined, such as the future of housing, plastics, computers, communications, insurance, education, and employee benefits. Institute research generally is conducted by means of such futures-analytic techniques as the Delphi method, cross-impact analysis, and simulation, as well as the more traditional methods of physical- and social-science research.

CONTENTS

PREFACE v

ACKNOWLEDGMENTS vii

I. BACKGROUND AND PURPOSE 1

- A. Introduction 1
- B. The Problem 3
- C. The Choices 7

II. STUDY APPROACH 9

- A. Identification of Critical Issues 9
- B. Selection of Experts 10
- C. Data Collection 11
- D. Data Integration 11

III. SUMMARY AND RECOMMENDATIONS 15

- A. Computers as Tools in Decision Making 16
- B. Computers as Elements in Operational Systems 19
- C. Computers as Shapers of Perceptions, Behavior, and Attitudes 21
- D. Evaluation of Program Areas 25
- E. Program Implementation 30

IV. WORKSHOP ON COMPUTER MODELING AND SIMULATION AS AN AID TO DECISION MAKING 33

- A. Workshop Participants 33
- B. Workshop Summary 33
- C. Candidate Program Areas 36
- D. Summary and Discussion of Invited Papers 41
- E. Guideline Questions for the Workshop 46

V. WORKSHOP ON COMPUTERS AND FINANCIAL PROCESSES 49

- A. Workshop Participants 49
- B. Workshop Summary 49
- C. Candidate Program Areas 52
- D. Panel Reports 55
- E. Preintegration Critiques 69
- F. Guideline Questions for the Workshop 72

VI. WORKSHOP ON COMPUTER PERCEPTIONS, ATTITUDES, AND LITERACY . . . 75

A. Workshop Participants 75
B. Workshop Summary 75
C. Candidate Program Areas 78
D. Summary and Discussion of Invited Papers 80
E. Panel Reports 84
F. Guideline Questions for the Workshop 90

VII. WORKSHOP ON COMPUTERS AND INDIVIDUAL ACCESS 93

A. Workshop Participants 93
B. Workshop Summary 93
C. Candidate Program Areas 96
D. Summary and Discussion of Invited Papers 99
E. Panel Reports 105
F. Guideline Questions for the Workshop 111

APPENDIX A: FRAMEWORK FOR ASSESSING SOCIAL IMPACT 113

APPENDIX B: BIOGRAPHIES OF WORKSHOP PARTICIPANTS 115

REFERENCES 131

PREFACE

In the spring of 1973 the Institute for the Future held a series of four workshops,* each focusing on a particular aspect of the social impact of computers: (1) computer models and simulations as aids to decision making; (2) the use of computers in financial operations; (3) perceptions, attitudes, and literacy regarding computers (i.e., knowledge about the capabilities and limitations of computers in meeting human needs); and (4) individual access to computers. The collective purpose of these workshops was twofold: to define some of the most important societal issues stemming from the present and potential uses of computers; and to formulate an effective program of study, research, and demonstration for achieving a better understanding of these issues.

This report reflects the distilled and collective judgments of approximately sixty workshop participants, supplemented by the research and analysis of the staff of the Institute for the Future. It poses questions rather than provides answers about the present and future social impact of computers. These questions convey two principal messages. The first is an *early warning* of the need to acquire a deeper understanding of how computers affect the decisions we make, the goods and services we produce, and the world we perceive. The second message is an *urgency* to begin the job of systematically acquiring this improved understanding *now,* before it is too late. A program for doing this is formulated and proposed herein; the estimated cost of this program is believed to compare very favorably with the perceived societal benefits of moving toward the development of a more humane and socially useful computer technology.

---

*A fifth workshop was held at the end of the series to help integrate and evaluate the results of the four preceding workshops.

ACKNOWLEDGEMENTS

This study represents the efforts of many people. First are the workshop participants,* whose collective judgments are reflected in the study findings. Next are the workshop cochairmen, who helped provide structure to the workshops: Dr. Willis Ware, Mr. Walter Carlson, Dr. John Meyer (assisted by Dr. Donald Farrar), and Mr. Paul Armer (who assisted in the workshop planning but was unable to participate in the sessions). To this list must be added the staff members of the Division of Computer Research, National Science Foundation, who provided guidance in the planning and execution of the workshops: Dr. John Pasta, Dr. Fred Weingarten, Dr. Granger Morgan, and particularly Dr. Peter Lykos, who was instrumental in bringing the workshop series into being. And finally are the following Institute staff members: Miss Bryna Ball, who helped in making arrangements for the workshop sessions, Mrs. Jeanne Muzzicato, who typed the final manuscript, and Mrs. Vicki Wilmeth, who was responsible for publishing the report.

---

*The participants are identified in Appendix B.

I. BACKGROUND AND PURPOSE

A. INTRODUCTION

The need for understanding the ways in which the future development and uses of technology may affect our lives has become urgently clear in recent years. Equally apparent is the need for understanding how changes in life style may, in turn, affect the future development and uses of technology. What is not so clear, however, is how these understandings are best obtained.

This study is an initial effort toward achieving a better understanding of the social impact of a group of society's most pervasive technologies--computer and computer-related technologies.* It does this by formulating a program of *retrospection, monitoring, experimentation,* and *education,* which is aimed at systematically achieving an improved understanding and at providing early indicators of both problems and opportunities.

One is tempted to use the rubric *technology assessment* to help describe what is being attempted here. However, *technology preassessment* is a more appropriate descriptor, for in fact, the groundwork has been laid for a focused set of detailed assessments.**

Literally hundreds of different aspects of the potential impact of computers on society might be identified and explored. Since the detailed assessment of any of these can be an expensive undertaking, it is necessary to establish a priority ranking among the principal candidate research areas. This preassessment study addresses precisely that problem.

---

*The term is defined to include the computer and the associated hardware and software technologies surrounding its application; namely, input/output devices, data banks, communications networks, programming languages, and so forth.

**National Academy of Engineering, Committee on Public Engineering Policy, *A Study of Technology Assessment*, Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969); National Academy of Sciences, *Technology: Process of Assessment and Choice*, Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969); and Martin V. Jones, *A Technology Assessment Methodology: Project Summary*, The Mitre Corporation (June 1971).

The approach used in this preassessment effort resembles the approach that would be used in a full assessment study, but with two major differences: first, evaluations of potential impacts are used to screen candidate areas rather than to study them in detail; and second, heavier reliance is necessarily placed on informed group judgments than on hard data.

One of the central concepts in establishing a priority ranking is that of *social impact*. In the context of this study, emphasis was placed *equally* on the *indirect* and/or *unintended* social consequences of computer technology and on the *direct* and/or *intended* consequences. This concept guided both the generation of candidate program areas and the assessment of their cost-effectiveness.

Although the intuitive meaning of social impact is fairly clear, the methods for assessing social impact operationally are far from being well understood or developed.* In this study, social impacts potentially ascribable to computers were characterized by a conceptual framework of three interacting elements. Each element, in fact, yielded a checklist of indicators that could be used to assess qualitatively the magnitude and nature of possible impacts. The first element of the framework represents the *information system* itself. Appropriate indicators for gauging changes are data rates, transfer paths, memory sizes, and the like. The second element represents the *social system* to which the information system is linked. The relevant indicators of change may be wealth, income, status, power, and so forth. And finally, the third element is the *value system*. Impacts in

---

*National Academy of Engineering, Committee on Public Engineering Policy, *A Study of Technology Assessment*, Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969); Hugh V. O'Neill, *A Technology Assessment Methodology: Computer Communications Networks*, vol. 3, MTR-6009, The Mitre Corporation (June 1971); Vary T. Coates, *Technology and Public Policy: The Process of Technology Assessment in the Federal Government*, vols. 1 and 2, Program of Policy Studies in Science and Technology, The George Washington University (July 1972); and Robert T. Holt, "Anticipating the Social Consequences of Technological Change", paper read at the Annual Meeting of the Division of Behavioral Sciences, National Academy of Sciences, 19-20 May 1972.

this area may make themselves felt as changes in privacy, choice, equality of opportunity, and the like. (See Appendix A.)

B. THE PROBLEM

Computer and computer-related technologies are affecting each of our lives in many subtle and not so subtle ways. Any number of measures can be used to gauge these effects. The most aggregated measures relate to the size and rate of growth of the computer industry itself. Within approximately a twenty-five-year period, the industry has grown from virtual non-existence to one which accounts for well over 100,000 computers worldwide, valued in excess of $20 billion. The number of computers is expected to be a shade under 500,000 by 1985,* with about two-thirds of these in use in the United States. In 1970 the total annual investment in this area in the United States represented about 0.6 percent of GNP; this is expected to grow to about 1.4 percent of GNP by 1985, a threefold increase from 1970 in constant dollars.** It is widely speculated that the computer industry (including related information services) is very likely to be the largest industry in the world by the turn of the century, if not sooner.

The present size and expected growth of the industry may indeed be among the poorest indicators of potential social impact. What is perhaps more relevant is the almost incredible pace of technological development. The use of a few measures will illustrate the point. In the past decade the *speed* of computation (i.e., using electronic components only) has increased by a factor of ten every four years, while the *size* of electronic components has decreased by about a factor of ten during this period. What is even more striking is that the *cost* of raw computing power has also decreased by a factor of ten every four years.*** And it appears that all of these trends will be sustained for the remainder of this decade--except that even more dramatic reductions in the size of electronic components are in the offing. It is difficult to visualize the effect such equivalent changes--particularly those related to cost--might have on the development and application of other technologies. But perhaps they explain in part why computers have acquired a foothold in an almost endless array of application areas and why growth continues unabated in those areas in which they are already well established. It is, in fact, difficult to identify any societal sector that is *not* either directly or indirectly affected by the use of computers.

---

*The most rapid growth is expected in minicomputers during this period.

**J. R. Salancik, Theodore J. Gordon, and Neale Adams, *On the Nature of Economic Losses Arising from Computer-Based Systems in the Next Fifteen Years*, Report R-23, Institute for the Future (March 1972).

***Paul Armer, *The Individual: His Privacy, Self-Image and Obsolescence*, presented to the U.S. Congress, House, Committee on Science and Astronautics, Panel on Science and Technology, Eleventh Meeting (January 1970).

The motivation for applying computers in any particular sector usually stems from a desire to reduce costs or improve efficiency, even though these objectives are not always realized in practice. In addition, the application of computers often makes it possible to accomplish tasks that would not have been otherwise practical, feasible, or safe--due to constraints of time or operational complexity. But the *indirect* effects that computers produce on the organizations in which they are used are perhaps even more important. Then, too, it is important to understand how computers are viewed and perceived by those individuals (e.g., managers, employees, and customers) whose lives are touched by them. Few data are available concerning the impact of computers on organizations--in terms of changes in goals, communication patterns, centralization or decentralization of decision making, and so forth. However, some rudimentary data on the effects of computers on individual perceptions and attitudes do exist.

As might be expected, individual perceptions of, and reactions to, computers are ambivalent. Positive attitudes generally result from viewing computers in medical, scientific, and technical applications. However, predominantly negative reactions are associated with the impact of computers on employment, privacy, depersonalization, and concentration of power.*

---

*Time Magazine and American Federation of Information Processing Societies, Inc., *A National Survey of the Public's Attitudes toward Computers* (New York: Time, 1971); Thomas L. McPhail, "How the Public Receives the Computer: Some Social-Psychological Dimensions", in Stanley Winkler, ed., *Computer Communications: Impacts and Implications*, Proceedings of the First International Conference on Computer Communication, Washington, DC, 24-25 October 1972; and Stanley Rothman and Charles Mosmann, *Computers and Society* (Chicago: Science Research Associates, 1972), pp. 213-251.

Most of these perceptions are not yet well developed, except possibly those dealing with the threats of unemployment. However, issues of personal privacy and depersonalization are seeping increasingly into public consciousness as a result of reported abuses in the handling of credit, health, and law-enforcement data. Perhaps less appreciated at this point is the extent to which computers may facilitate the acquisition, concentration, and manipulation of political or economic power.*

This is not to suggest that no efforts have been made to assess the impact of computers; but rather that such efforts have been largely fragmented, uncoordinated, and ad hoc. For example, in 1965 the National Commission on Technology, Automation, and Economic Progress commissioned some short studies aimed at exploring the impact of computers on several specific industries.** In 1967 the first thoroughgoing study of privacy was completed by A. F. Westin*** (supported by a grant from the Carnegie Foundation). More recently, in 1972 the results of a comprehensive study were reported by A. F. Westin and M. Baker (supported by the National Academy of Sciences and the Russell Sage Foundation) on the impact of privacy and due process on both manual and computerized record-keeping processes.**** And in the past year (1973), both the Advisory Committee [to the Secretary of the Department of Health, Education, and Welfare] on Automated Personal Data Systems and the National Commission on Criminal Standards and Goals have highlighted the basic issues that must be resolved in connection with the record-keeping functions of public agencies.***** These and related efforts have served to call attention to the necessity for administrative actions, legislative measures, and surveillance efforts aimed at achieving an effective balance of the requirements for privacy, due process, and efficiency in record-keeping operations. But very little has been done in studying other potentially important social-impact areas.

---

*See Rothman and Mosmann, op. cit., pp. 243-245, for an interesting account of the use of computer data analysis in a political campaign.

**Paul Armer, *Computer Aspects of Technological Change, Automation, and Economic Progress*, Report to the National Commission on Technology, Automation, and Economic Progress (September 1965); and Merrill Flood, *Commercial Information Processing Network--Prospects and Problems in Perspective* (September 1965).

***Alan F. Westin, *Privacy and Freedom* (New York: Athenium Publishers, 1967).

****A[lan] F. Westin and M. Baker, *Databanks in a Free Society* (New York: Quadrangle Press, 1972).

*****U.S. Department of Health, Education, and Welfare, Secretary's Advisory Committee on Automated Personal Data Systems, *Records, Computers, and the Rights of Citizens*, DHEW Publication No. (OS)73-94 (July 1973).

This situation should perhaps not be altogether surprising for such "other" effects are somewhat more subtle and still not clearly visible. True, job displacement and unemployment generally produce direct, highly visible, and immediate effects; however, issues of depersonalization and issues of privacy are a bit more subtle--at least initially. To be sure, many have experienced the loss of "personal touch" in credit-handling and billing transactions, or may have become aware that information on federal tax returns is also available to others (e.g., state agencies); but even here it is likely that most Americans would yet not identify such issues as major social concerns.

This relative unawareness is due, in part, to the nature of the impacts themselves. Most of the social effects of air pollution, transportation congestion, and energy shortages--when they occur--are not only physical but also tangible and readily perceived. This is not the case when social effects stem from information-system changes that alter decision-making processes, communication patterns, or power balances. Even in a society whose activities are increasingly shaped by information technologies, such impacts seem too diffuse and intangible to be grasped readily, if at all.

The effects--no matter how subtle--are nonetheless of critical importance to society. They can affect the basic structure and fabric of society for they have an influence on how we make decisions, how we organize to produce goods and services, and even how we perceive the world around us. For example, decision makers, in both the public and private sectors, are becoming increasingly dependent on the outputs of computer models to guide resource allocations, to forecast economic developments, and to evaluate military strategic options. Similarly, the alteration of information-flow patterns produced by computer applications is having a profound effect on the structure, objectives, and efficiency of organizations and entire industrial sectors. But perhaps the most important social effects are those linked to the ways in which contact and experience with information systems affect the image of one's self and the world in which one lives. Included here are questions of the possible inhibiting effects of personal-information availability on behavior (how is individual behavior modified?), the role of the computer as a mediating agent in interpersonal transactions (what is the effect on feelings of isolation or belonging?), and the impact of computers on one's self-image as an intelligent, rational being (what is the effect on man's psyche?).

C. THE CHOICES

There are several possible strategies for dealing with the issues outlined above. The first is to wait--wait until the effects now only dimly perceived become more visible. This is what the program proposed herein seeks to avoid, for it is believed that the penalties for, and missed opportunities of, not acting now are high. A closely related strategy is to "muddle through", that is, to respond to problems on an essentially ad hoc basis. But the pace of change--as well as the complexity and extensiveness of the potential impacts--makes this an unnecessarily hazardous course to pursue. Still another possible strategy is to embark on a program of particularized technology assessments and analyses aimed at forestalling or minimizing problems and exploiting opportunities. At present no effective tools exist for doing this convincingly, although the recommended program lays the groundwork for ultimately making such assessments.

The course proposed here is to structure a program of study and action--including *retrospection, monitoring, experimentation,* and *education*--that can provide early warning on the critically important issues and that can also reflect a sense of priorities for action. The time remaining for doing this is getting uncomfortably short. It is true that the most recent study by Westin and Baker* shows that computer applications are not yet appreciably altering the balance between information policies of organizations and individual rights to privacy. However, this balance is changing rapidly and a systematic monitoring program to provide guidance for action (e.g., legislation) is warranted. And it is even more important to capture the initiative in the still less visible impact areas noted earlier.

---

*Westin and Baker, op. cit.

The price for inaction can be high, as evidenced by our failure to do systematic assessments for other socially pervasive technologies, such as television. Scattered efforts have been made to assess the impact of television on the behavior of children, and some data is available on the social and cultural impact of television in certain developing countries.* But, on the whole, these efforts have been too late and too fragmentary in proportion to the magnitude of the effects that have been produced. The same may be said for other socially widespread technologies, either in retrospect or prospect (e.g., the automobile or the telephone). However, a number of proposals now exist for comprehensive social assessments of a variety of communications media, including the telephone and teleconferencing.**

**Television and Growing Up: The Impact of Televised Violence* (Washington, DC: U.S. Government Printing Office, 1972); and Wilbur Schramm and Daniel Lerner, eds., *Communication and Change in Developing Countries* (Honolulu: East-West Center Press, 1967).

**Alex Reid, *New Directions in Telecommunications Research*, Report to the Alfred P. Sloan Commission on Cable Communications (June 1971).

II. STUDY APPROACH

As previously noted, the objective of this study was twofold: (1) to define some of the critical societal issues arising from present and potential uses of computers; and (2) to structure a research program aimed at achieving a better understanding of these issues. The purpose here is to describe both the rationale and the steps of the study approach.

A. IDENTIFICATION OF CRITICAL ISSUES

The problem of identifying critical societal issues related to computer impact is identical to the more general issue-identification problem that exists at the beginning of any broad inquiry. What specific areas should provide the focus for the detailed exploration?

The basic rationale for selection was: at least one critical issue area should be *process-oriented* or should cut across a number of computer-application areas; at least one should be *applications- (or sector-) oriented;* and at least one should be strongly *value- (or choice-) oriented*. Beyond this, some general criteria were used in the search; namely, the potential social-impact areas should be extensive in scope and, more importantly, future-oriented.

The selection process was largely iterative. Major dependence was placed on the judgments of knowledgeable researchers at the Institute for the Future and the National Science Foundation, supplemented by selective contact with several consultants outside these organizations. The choice of a process-oriented area (i.e., models and simulations) and an applications-oriented area (i.e., the financial sector) were fairly straightforward compared to the selection of the value-oriented areas (perceptions, attitudes, literacy, and access).

Once each critical issue area had been agreed upon, the specific subissues that were to provide the focus for a detailed inquiry were formulated.

For each issue, a set of guideline questions was drawn up. These provided the basis for both additional Institute research and the search for experts (or participants) whose points of view were to be elicited.

B. SELECTION OF EXPERTS

Each issue area (and its related subissues) was quite broad in scope. No single individual could be expected to be knowledgeable in any but a small part of any such area. Further, since each issue area was intrinsically future-oriented, heavy reliance necessarily had to be placed on individual judgment and personal perception. Thus, whatever the particular data-collection mechanism used, access to the diverse views of a set of carefully selected individuals was of critical importance.

Several general criteria were used in the search and selection processes. First, of course, individuals were sought whose backgrounds matched the subissues developed in the guideline questions. Second, priority was given to those individuals with backgrounds that showed evidence of concern with the larger environment in which computers function and are perceived. Third, a determined effort was made to select individuals who were likely to represent diverse or conflicting views* of possible future developments. And, finally, in some instances, a conscious choice was made of particular individuals whose substantive expertise was somewhat "peripheral" to the major issue areas involved.

The process by which these selection criteria were applied was systematic, but largely empirical. An initial roster of approximately 150 candidate experts was drawn up from literature searches, personal knowledge, and solicited references. For each candidate, biographical data was collected and relevant publications searched. Approximately 70 invitations were issued to candidates in order to acquire the targeted 60 who participated in the study. This provided 10 to 15 contributors for each of the four major issue areas selected--a group size consistent with empirical data collected by the Institute and others.*

---

*For example, the participants in the Workshop on Computer Models and Simulations represented competences in ten different substantive fields: physical sciences, defense systems, financial planning, corporate planning, econometrics, health services, urban planning, regional planning, environmental systems, and ecology.

C. DATA COLLECTION

Any number of methods might have been used, singly or in combination, to elicit data from the invited contributors: personal interviews, questionnaires, invited papers, workshops, and perhaps even teleconferences. Heavy reliance was placed in this study on structured, face-to-face workshops in order to exploit the *interactive* quality of this communication mode.

A series of four two-day, data-collection workshops was held over a period of three months. Each of the workshops was structured around one dominant issue area: (1) computer modeling and simulation as an aid to decision making; (2) computers and financial processes; (3) computer perceptions, attitudes, and literacy; and (4) computers and individual access. Although some variations existed in the ways the workshops were structured, the basic pattern included the following three elements: presentation of papers by three or four participants who addressed specific guideline questions and issues; reports from several panels organized around specific issues generated during workshop discussions; and generation, distillation, and evaluation of a list of candidate research program areas.**

D. DATA INTEGRATION

The summary and integration of data was done in two distinct stages. The first stage occurred at the end of each of the four data-collection

---

*Norman Dalkey et al., *Studies in the Quality of Life* (Toronto: D. C. Heath and Co., 1972).

**A review of Chapter III, Summary and Recommendations, will not provide the reader with a clear and accurate sense of both the dynamics of the workshop sessions and the differing and often conflicting views that were aired. For this, the reader is urged to turn to Chapters IV, V, VI, and VII.

workshops described above. The second stage occurred at a fifth (integrating) workshop held several months later.

First Stage

Several hours before the close of each data-collection workshop, the participants were asked to identify and describe (in writing) the *most important* program areas stemming from the workshop presentations and exchanges. *Important* at this point was defined generally as "degree to which a contribution is made to understanding social impact". Inputs from each participant were collected, summarized, and then fed back to the participants in a closing workshop session.

In this final session, candidate program areas were redefined, aggregated, and fleshed out. Each participant was asked to evaluate (in writing) all of the candidate program areas in terms of both researchability (on a rating scale of 1 to 3) and importance (priority ranking).* These evaluations were then combined, and the five top-ranked program areas from each workshop were used as inputs for the integrating workshop.

Second Stage

The final data integration was done at the fifth workshop, attended by two participants from each of the four preceding workshops and two observers from the National Science Foundation. The starting point was the twenty top-ranked program areas distilled from the data-collection workshops.

The first step was the review, redefinition, and consolidation of the twenty candidate program areas--including, at times, going back to the original workshop summaries for relevant inputs that might have been overlooked. This process resulted in a modified list of nineteen program areas. (See Chapter III, Summary and Recommendations.)

---

*Participants in the Workshop on Computers and Individual Access did not favor using formal rating or ranking schemes for preference ordering. Instead, the evaluation inputs from the participants at this workshop were used for general guidance only.

The next step was the specification of the framework and criteria for the final selection and evaluation of program areas.* It was determined that each candidate program area would be evaluated with respect to three major criteria:

- rating, on a scale of 1 to 5, of its contribution to the understanding of social impact, if the program were successful (see Appendix A);
- probability of success, if the program were adequately funded; and
- minimum support level required, broken down in terms of cost per year and number of years.

The final evaluation process comprised two distinct rounds. In each round, participants provided estimates of the parameters described above. (See Figure 1.) Averages of estimated quantities in the first round were computed, tabulated, and fed back to the participants. Opportunity was then provided for the participants to discuss the reasons for major deviations from these averages before reestimates were provided of all quantities in the second round.

---

*The method used has been adapted from a prior study at the Institute for the Future: Olaf Helmer and Helen Helmer, *Future Opportunities for Foundation Support*, Report R-11 (1970).

Figure 1. FORM USED IN FINAL EVALUATION OF CANDIDATE PROGRAM AREAS

CANDIDATE PROGRAM AREA	PROBABILITY OF SUCCESS IF ADEQUATELY SUPPORTED*			CONTRIBUTION TO UNDERSTANDING OF SOCIAL IMPACT (OR IMPORTANCE) IF SUCCESSFUL*			MINIMUM SUPPORT LEVEL					
							First Estimate		Mean		Second Estimate	
	1st Est.	Mean	2nd Est.	1st Est.	Mean	2nd Est.	K$/Yr	# Yrs	K$/Yr	# Yrs	K$/Yr	# Yrs
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

*Using a scale of 1 to 5, 1 = virtually no contribution to understanding, 3 = moderate contribution to understanding, and 5 = strong contribution to understanding, with 2 and 4 representing intermediate values.

III. SUMMARY AND RECOMMENDATIONS

Nineteen research program areas* have been identified and formulated as key in achieving a growing understanding of the social impact of computers in the next decade. These were distilled from the more than fifty candidate areas generated at the four workshops on computer impact. The nineteen final areas are structured in three major groupings, reflecting three different dimensions of social impact:** (1) computers as tools in decision making; (2) computers as components in operational systems; and (3) computers as shapers of perceptions, behavior, and attitudes of individuals and groups (both interpersonal and institutional effects). The proposed program areas are listed below.

Group A: Computers as Tools in Decision Making

A1. Retrospective Studies of Models, Modelers, and Modeling Processes
A2. Values and Cognitive Styles of Model Builders
A3. Role of Group Judgment in Modeling
A4. Data-Base Requirements for Models
A5. Interface between Model Builders and Model Users
A6. Validation of Computer Models

Group B: Computers as Components in Operational Systems***

B1. Structure and Regulation
B2. Economies of Scale
B3. Standardization
B4. Audit Trail, Surveillance, Security, and Fraud

---

*As mentioned earlier, the program areas include four distinct kinds of activities: retrospection (e.g., the impact of information systems on institutional goals); monitoring (e.g., invasions of personal privacy); experimentation (e.g., the social psychology of information systems); and education (e.g., computer literacy). The general term *program* is used to designate the entire collection of program areas.

**Some inevitable overlap exists among the three categories.

***The financial sector (i.e., banking, insurance, and securities industries) is used as the prototype application area.

Group C: Computers as Shapers of Perceptions, Behavior, and Attitudes

C1. Retrospective, Comparative, and Case Studies of the Impact of Information Systems
C2. Humane Design Criteria for Information Systems
C3. Requirements for Computer and System Literacy
C4. Computer Literacy for Decision Makers and Opinion Leaders
C5. Regulatory and Competitive Dimensions of Access
C6. Behavioral Consequences of Information Availability
C7. Conflict between the Right to Know and Personal Privacy in Information-System Design
C8. Aggregation of Individual Value Judgments and Mediation of Interpersonal Communication
C9. The Social Psychology of Information Systems

A. COMPUTERS AS TOOLS IN DECISION MAKING*

Computers can assist decision making in many ways. But perhaps one of the most important is the use of computers in model building and simulation. In computer modeling, the most basic questions do not deal with the intricacies of building specific models or the design of special languages. Rather, the key questions are: How is a model to be built? What should it include? How is it to be validated? These questions reflect the largely ad hoc nature of modeling as it is now practiced, where specific models are built to meet particular needs.

Even so, it is interesting to note the variety of ways in which the use of computer models can impact society in decision-making contexts. In particular they can: (1) provide structure in defining the decision to be made; (2) make it possible to cope with a compressed time scale; (3) provide a richer choice-set; (4) contribute to "variance reduction" in evaluating a set of possible outcomes; (5) become an independent factor in the decision process; (6) give the decision maker the courage to act; and (7) strengthen the notion of intentionality in human affairs.

The following six candidate program areas address many of the fundamental issues related to the social impact of computer models.

---

*See Chapter IV for a detailed description of the proceedings leading to the recommendations contained in this section.

A1. Retrospective Studies of Models, Modelers, and Modeling Processes

Retrospective studies should be designed to improve general standards and practices in modeling. Those factors that result in success or failure need to be identified and evaluated (e.g., activities that deal with "tuning" or "adjustment" of models, as well as the heuristic learning that takes place with model use); and the characteristics of "good" models (e.g., level of detail and aggregation) need to be studied. In a very pragmatic sense, models may achieve credibility either by being on the "winning side" or by alerting the decision maker (e.g., when using a corporate model) not to take a particular action; however, the quality, availability, and timeliness of documentation can also be very important ingredients in determining model success.

Caution should be exercised in the extrapolation of general principles from individual retrospective studies since some question exists on the extent to which the results of such studies may be generalizable.

A2. Values and Cognitive Styles of Model Builders

Research should be aimed at achieving two objectives: (1) the development of ways to structure models so that the value framework of the model builder is made as explicit as possible; and (2) the identification of the basic elements of cognitive styles of successful modelers and the development of useful criteria for identifying and training such individuals.

It is recognized that value-free modeling is unattainable. However, by examining such values, one should be able to weight their influence on model structure and model outputs.

A3. Role of Group Judgment in Modeling

Methods for the collection, integration, and incorporation of multidisciplinary inputs from several experts to derive information on model structure and coefficients need to be explored. Considerable emphasis should be placed on the role of modeling as a communication and integrating vehicle to help bridge organizational boundaries and to compensate for conflicting assumptions and externalities. Because the use of group judgment in problem solving clearly transcends its application in modeling, it may be that this application should be pursued in conjunction with other efforts for enhancing group communication and problem solving.

A4. Data-Base Requirements for Models

Research should be aimed at the development of procedures for achieving a balance between the characteristics of a model (e.g., structure and cost) and its data requirements (e.g., sources, costs of acquisition, and error tolerances). Particular attention should be given to the creation of packages of general reformatting and "data-scrubbing" programs that can be used with data bases that are incomplete, fragmentary, or involve different time frames.

A5. Interface between Model Builders and Model Users

At least two important study areas exist here: (1) the development of more effective ways to couple the varying skill levels of users of a model to the model-building process; and (2) an analysis of the behavior of a decision maker when confronted with a number of decision-making inputs, one or more of which is derived from a computer model. Methods used by decision makers in weighting information inputs from several sources should also be explored.

A6. Validation of Computer Models

There is an urgent need to develop procedures for judging the degree to which a model resembles the "slice of reality" it purports to represent. This is particularly true for models representing social systems, where there are no well-developed procedures for validation.

The process of validation can sometimes be done by comparing the model with laboratory experiments; sometimes by comparison to test cases that can be handled by other methods; sometimes by comparison to history; and sometimes by comparison with common sense, intuition, or professional judgment. Validation may involve an examination of the structure of the model, the algorithms that are used to solve the mathematics, the computer-program representation of the structure, or the determination of parameters and special output features (including "pathological" cases in which the output behaves unexpectedly). The precision with which validation must be done really hinges on the purposes of the model.

It is probable that validation may not be possible except on a case-by-case basis, even though the validation procedures may be similar. In any case, only when the validity of a model can be ascertained can sound judgments be made about the relevance of its results.

B. COMPUTERS AS ELEMENTS IN OPERATIONAL SYSTEMS*

Somewhat orthogonal to the uses of computers as tools in decision making are their uses as elements in operational systems. And for this, any number of application sectors might have been selected. The financial sector turned out to be a particularly good one since computers have a long history of usage here, and considerable data on impact are available. It may thus be regarded as a prototype for other computer-application sectors. It is interesting to note some of the possible social impacts of computers in the financial sector: (1) creating payment mechanisms that are more vulnerable to "overload" and "crashing"; (2) forcing reexamination of economy-of-scale arguments that may be obsolete; (3) encouraging subtle concentrations of power; (4) creating a new class of privacy issues stemming from the role of financial intermediaries; and (5) perpetuating processing systems that should have been discarded.

B1. Structure and Regulation

Research should be aimed at an analysis of the relationship of industry structure to regulation in the financial sector and the ways in which this structure (and its relationship to regulation) may be modified by the application of computer technology. Key study areas include: (1) the intent, impact, and cost-effectiveness of regulation; (2) the relative growth of integrated or specialized services; (3) the impact of new services and repackaging of old services on industry structure; (4) the regulatory implications of technological innovations; and (5) marketing and distribution systems of financial intermediaries, particularly economies of cross-selling services.

---

*See Chapter V for detailed descriptions of the proceedings leading to the recommendations contained in this subsection.

B2. Economies of Scale

The extent to which economies of scale exist in the financial sector is not known; nor is it known how these are being modified by applications of the computer. Study areas should include: (1) a determination of the existence of, and distinctions between, aggregate and unit economies of scale; (2) comparisons of large-scale computer systems to minicomputers and communication links; (3) the competitive impact of joining trading and post-trading execution systems; (4) the applicability of economies of scale to production-function characteristics of an organization's product/service outputs; and (5) the relationship of economies of scale to industry structure, natural monopolies, and regulatory options.

B3. Standardization

The relative merits of technical and operational standardization in the financial sector need to be explored from both cost-benefit and jurisdictional standpoints. Key areas would include: (1) the purposes, nature, and timing of standards; (2) communication system/user interface standards; and (3) the relationship of standards to economies of scale, monopolistic tendencies, and interfacing requirements.

B4. Audit Trail, Surveillance, Security, and Fraud

Potential computer-related abuses created by the increasing automation of the financial sector need to be identified and analyzed. Study areas should include: (1) the economics of audit-trail implementation for monitoring the quality and propriety of decisions; (2) the development of new sets of "pattern indicators" to detect abuses; and (3) the relationship of surveillance methods and standardization choices.

C. COMPUTERS AS SHAPERS OF PERCEPTIONS, BEHAVIOR, AND ATTITUDES*

At a higher level of abstraction than the use of computers as tools for decision making or as operational system elements is their role as shapers of social behavior. This role is a composite of the behavioral impact of perceptions about, and access to, computers.

The candidate program areas are predicated on the notion that widespread knowledge about computers is the best defense against possible hazards and provides the best platform for realizing potential benefits. The nine areas in this section span an extremely wide range of activities. Two deal essentially with existing systems to determine the impact such systems are having both on their users and on related institutions. Particular concern here is aimed at developing and applying humane design criteria. Another two areas deal with long-term and short-term educational needs for achieving computer literacy at various societal levels. Because structural factors within the information-system industry itself may affect access to computers for individuals and groups, one area deals exclusively with the regulatory and competitive aspects of access. The four remaining areas are concerned with understanding some of the most difficult personal effects of computers. Included here are the inhibitory effects of information availability on individual and group behavior, the search for principles for balancing requirements of personal privacy and the right to know, the role of computers as mediators of interpersonal communications and relations, and--perhaps the most difficult area of all--the effects of computer access on one's perceptions of oneself and the outside world.

C1. Retrospective, Comparative, and Case Studies of the Impact of Information Systems

Research should be aimed at two objectives. The first is the study of the ways in which the application of information systems serves to modify institutional objectives and purposes. Included here are: (1) public-policy issues of efficiency vs. privacy and social uniformity vs. diversity;

---

*See Chapters VI and VII for detailed descriptions of the proceedings leading to the recommendations contained in this section.

and (2) an assessment of secondary and higher-order impacts of proposed information systems on institutions of all kinds.

The second objective is the systematic review of computer-system applications to assess their impacts (e.g., skill levels required and style of information used) on system designers, managers, and users, as well as on the public at large. Included in the range of investigations are: (1) transitions from manual to computerized systems; (2) the impacts of increased access on keepers of information systems; (3) the relationship of access to social control; and (4) comparative analyses of access using international systems (e.g., Swedish income tax) as referrants.

C2. Humane Design Criteria for Information Systems

Information-system features that ensure responsiveness of such systems to a wide range of individual choices must be identified and utilized. Included here should be: (1) a detailed study of the concerns of the various groups interfacing with computer systems; (2) the identification of gaps between these concerns and the characteristics of present systems; (3) the structuring of remedial action programs; and (4) an assessment of the costs and benefits. Corrective programs might involve a variety of methods for achieving personal differentiation, including input-identification systems, the tailoring of services to individual needs, and the humanization of the information system/user interface.

C3. Requirements for Computer and System Literacy

Basic computer functions must be understood at various societal and educational levels. Research should be aimed at raising the level of public awareness so that computer systems could be exploited more fully and possible abuses avoided. This effort should include the structuring of broad educational programs, spanning grade school through college and continuing adult education. At the grade-school level, the new math could be adapted to include some "hands-on" time with computers so that direct experiences can be obtained by students from the beginning. At the high-school level, the need is for completely new courses, taken by *all* students, which convey information on the technical and operational features of computers, as well as their present and potential social impact. At the college level, a basic instructional unit for first-year students should provide direct and active experience with the computer in a multidisciplinary setting (i.e., drawing together students from a variety of disciplines).

C4. Computer Literacy for Decision Makers and Opinion Leaders

Decision makers and opinion leaders in both the public and private sectors must gain an understanding of basic computer applications; and appropriate processes for transferring such knowledge must be designed. The objective here should be to produce a more immediate increase in awareness of the capabilities, limitations, and costs of computers than would be possible with the more broadly based, long-term efforts discussed in program area C3 above. Particular care would have to be exercised to prevent such efforts from being, or appearing to be, lobbying exercises for computer sciences or technology.

C5. Regulatory and Competitive Dimensions of Access

Structural factors within the information-services industry (including natural monopoly, centralization vs. decentralization, and vertical integration) need to be analyzed and evaluated in terms of their influence on intraindustry competition and access. Included should be: (1) retrospective analyses of regulatory developments in the communication and computer industries; (2) the relevance of natural-monopoly considerations; (3) legal barriers to access; and (4) a definition of *public record*.

C6. Behavioral Consequences of Information Availability

Measuring mechanisms need to be developed and experiments must be designed for collecting data which indicate the possible effects of increasing availability of personal information on behavior. The range of explorations might include detection of behavioral changes arising from such stimuli as: (1) the operation of the Bank Secrecy Act* (e.g., incidence of transactions under $5,000); (2) records on political activity of particular social groups; and (3) the nature of medical records keeping (e.g., extent of quantitative vs. subjective data used).

C7. Conflict between the Right to Know and Personal Privacy in Information-System Design

Research should be aimed at the development of basic principles with which to balance the conflicting requirements of access and due process at both individual and organizational levels. Included here should be: (1) the development of operational definitions and taxonomies of access and privacy; (2) the structuring of generic case studies of conflict, together with assessment of costs and benefits; (3) the identification of anomalies and inconsistencies; and (4) comparative analyses of international systems.

C8. Aggregation of Individual Value Judgments and Mediation of Interpersonal Communication

The focus of the research should be an examination of the capabilities of computer-facilitated access in interpersonal communication. Included here would be a variety of mechanisms for mediating among geographically separated individuals (e.g., teleconferencing, citizen participation in governance, complaint aggregation and processing, dial-a-bus, and consumer/producer matching).

C9. The Social Psychology of Information Systems

The construction of cognitive maps of the impact of access on perceptions, behavior, and attitudes of individuals and social groups contains two principal components. The first is the development of a continuously updated data base on computer perceptions, behavior, and attitudes of individuals and groups with respect to present and anticipated uses of the computer. This should be done as part of a broader program of monitoring public attitudes toward technology and technological change. The data resulting from these efforts should be incorporated in the design of programs for education and training.

---

*The Bank Secrecy Act was passed in 1970 to curb violation of U.S. laws and federal tax evasion by use of secret foreign bank accounts and foreign financial transactions. Records are to be kept of individual transactions involving the import or export of $5,000 or more in currency or other instruments.

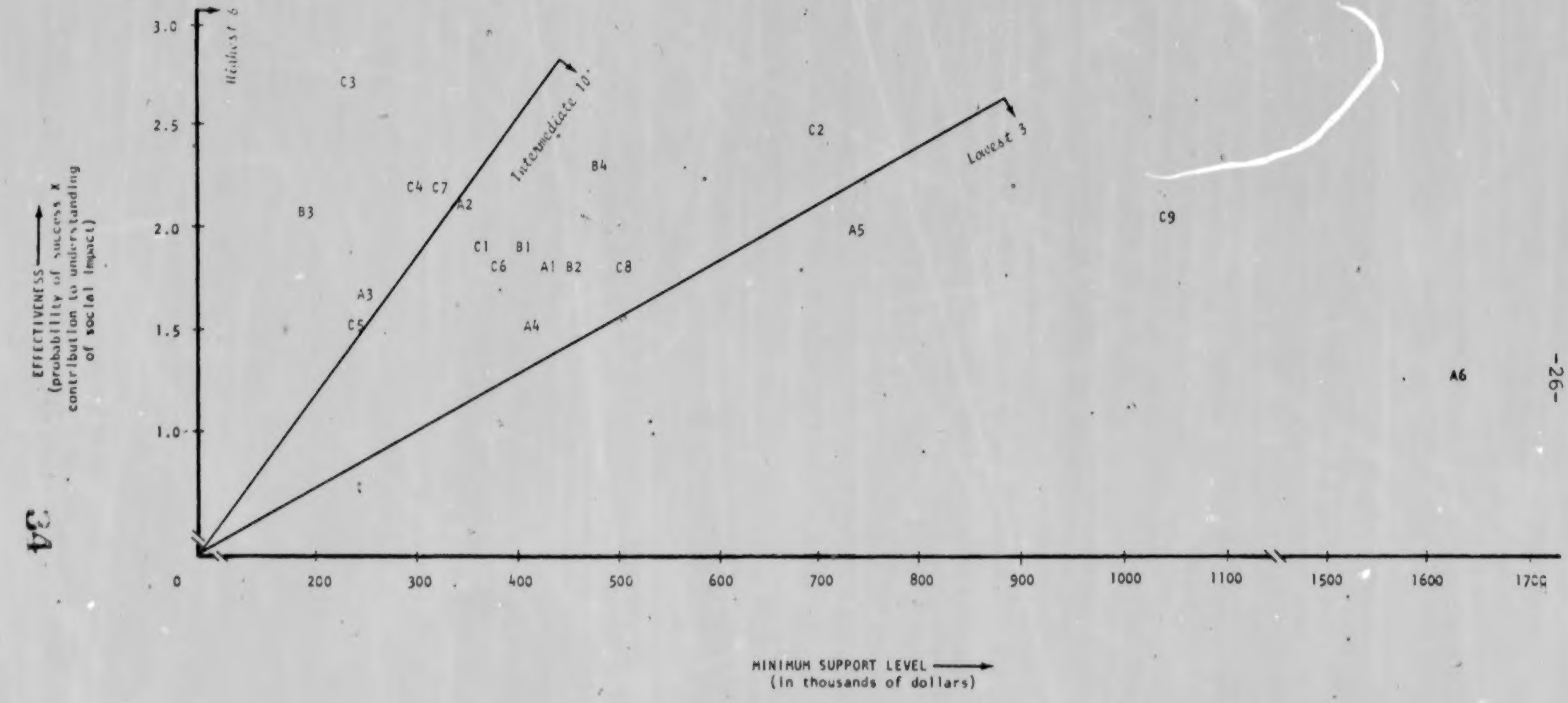
The second component is the design of experiments for understanding the manner in which contact and experience with information systems affects one's image of the world. Included should be: (1) experiments designed to detect and evaluate behavioral differences resulting from various information-access environments; (2) matched-group experiments (e.g., differences in perceptions between computer-science majors and humanities majors, differences in decision-making procedures between managers who rely on "management information systems" and those who do not, and so forth); and (3) a study of the impact of access on the selection of measures of system performance, particularly whether sophisticated and quantitative measures drawn from operationally oriented data bases become the intellectual currency for decision making and policy debate.

D. EVALUATION OF PROGRAM AREAS

As mentioned earlier, each of the nineteen program areas noted above was evaluated and rated with respect to three criteria: (1) the probability of achieving its stated objectives, if adequately funded; (2) the contribution to understanding social impact, if its objectives were achieved; and (3) the minimum support level required to achieve its objectives. The product of items 1 and 2 above was used as a relative measure of effectiveness, while item 3 was used as a direct measure of cost.

A graphic presentation of the cost-effectiveness of the nineteen program areas is shown in Figure 2. In this figure, measures of effectiveness are plotted against estimated minimum support levels to produce a scatter diagram of the nineteen program areas. If a line pivoted at the origin is swept clockwise from a full vertical to a full horizontal position, the nineteen program areas will be "touched" in approximate order of their relative cost-effectiveness. A listing of the program areas in that order is given in Figure 3.

Figure 2. EFFECTIVENESS VS. MINIMUM SUPPORT LEVEL FOR RECOMMENDED PROGRAM AREAS



KEY:

A1 = Retrospective Studies of Models, Modelers, and Modeling Processes
A2 = Values and Cognitive Styles of Model Builders
A3 = Role of Group Judgment in Modeling
A4 = Data-Base Requirements for Models
A5 = Interface between Model Builders and Model Users
A6 = Validation of Computer Models
B1 = Structure and Regulation
B2 = Economies of Scale
B3 = Standardization
B4 = Audit Trail, Surveillance, Security, and Fraud

C1 = Retrospective, Comparative, and Case Studies of the Impact of Information Systems
C2 = Humane Design Criteria for Information Systems
C3 = Requirements for Computer and System Literacy
C4 = Computer Literacy for Decision Makers and Opinion Leaders
C5 = Regulatory and Competitive Dimensions of Access
C6 = Behavioral Consequences of Information Availability
C7 = Conflict between Right to Know and Personal Privacy in Information-System Design
C8 = Aggregation of Individual Value Judgments and Mediation of Interpersonal Communication
C9 = The Social Psychology of Information Systems

Figure 3. PROGRAM AREAS IN ORDER OF ESTIMATED COST-EFFECTIVENESS

C3. Requirements for Computer and System Literacy

B3. Standardization

C4. Computer Literacy for Decision Makers and Opinion Leaders

A3. Role of Group Judgment in Modeling

C7. Conflict between Right to Know and Personal Privacy in Information-System Design

C5. Regulatory and Competitive Dimensions of Access

A2. Values and Cognitive Styles of Model Builders

C1. Retrospective, Comparative, and Case Studies of the Impact of Information Systems

B4. Audit Trail, Surveillance, Security, and Fraud

C6. Behavioral Consequences of Information Availability

B1. Structure and Regulation

A1. Retrospective Studies of Models, Modelers, and Modeling Processes

B2. Economies of Scale

C2. Humane Design Criteria for Information Systems

C8. Aggregation of Individual Value Judgments and Mediation of Interpersonal Communication

A4. Data-Base Requirements for Models

A5. Interface between Model Builders and Model Users

C9. The Social Psychology of Information Systems

A6. Validation of Computer Models

The six most cost-effective areas are those dealing with achieving computer literacy (both for the public at large and opinion leaders), the impact of computers on industry standardization, the development of generalized privacy-vs.-right-to-know criteria, the use of group judgment in modeling, and the competitive and regulatory dimensions of computer access. The three least cost-effective are judged to be those dealing with the interface between model builders and users, the social psychology of information systems, and validation of computer models.

Ranking program areas on the basis of cost-effectiveness ratios illustrates only one of several possible criteria for funding priorities that might be used. It is conceivable that the estimated effectiveness of some program areas might be large enough to warrant supporting them even though the estimated costs for doing so may be quite high. This would be particularly true if a program area were divided into smaller subunits. For these reasons a companion ranking by effectiveness measure only is shown in Figure 4 so that it may be compared to the cost-effectiveness ranking in Figure 3. It is interesting to note that three of the nineteen program areas rank among the top six with respect to both measures: the two dealing with computer literacy (both for the public at large and opinion leaders), and the development of privacy-vs.-right-to-know criteria. Three new program areas emerge in the top six when the ranking is by effectiveness only: the development and application of humane design criteria; the identification and analysis of computer-related abuses (e.g., audit trail, surveillance, security, and fraud); and the study of values and cognitive styles of model builders. It is also interesting to note that computer-model validation ranks at the bottom of both lists. This is certainly *not* due to its poor rating with respect to its "contribution to understanding social impact"; it, in fact, ranks highest of all program areas in this respect. Rather, its poor showing in the cost-effectiveness list is due to the magnitude of estimated cost, while its bottom rank on the "effectiveness only" list is due to the high-risk (low probability of success) nature of the research proposed.

The *total* estimated cost (for minimum support) of *all* program areas is approximately $10 million--spread over a period of three to five years.

Figure 4. PROGRAM AREAS IN ORDER OF ESTIMATED EFFECTIVENESS

C3. Requirements for Computer and System Literacy

C2. Humane Design Criteria for Information Systems

B4. Audit Trail, Surveillance, Security, and Fraud

C4. Computer Literacy for Decision Makers and Opinion Leaders

C7: Conflict between Right to Know and Personal Privacy in Information-System Design

A2. Values and Cognitive Styles of Model Builders

B3. Standardization

C9. The Social Psychology of Information Systems

A5. Interface between Model Builders and Model Users

C1. Retrospective, Comparative, and Case Studies of the Impact of Information Systems

B1. Structure and Regulation

C6. Behavioral Consequences of Information Availability

A1. Retrospective Studies of Models, Modelers, and Modeling Processes

B2. Economies of Scale

C8. Aggregation of Individual Value Judgments and Mediation of Interpersonal Communication

A3. Role of Group Judgment in Modeling

C5. Regulatory and Competitive Dimensions of Access

A4. Data-Base Requirements for Models

A6. Validation of Computer Models

This amounts to between $2 and $3 million per year. Even if, for safety's sake, the estimated minimum support level is multiplied by a factor of two to three, the total yearly cost to support the nineteen program areas is then estimated to be between $5 and $10 million. To be sure, these areas are not exhaustive in any sense and jointly cover only a segment of the social-impact spectrum. Nevertheless, this appears to be a surprisingly modest cost for the launching of a coordinated and sustained program aimed at understanding (and ultimately guiding) the humane and efficient development of a group of society's most pervasive technologies.

E. PROGRAM IMPLEMENTATION

A wide variety of agencies and institutions from both the public and private sectors could join in support of selected portions of the proposed program. Chief among these is the National Science Foundation, including the Division of Computer Research (e.g., social impact of modeling and simulation) and Research Applied to National Needs (e.g., technology assessments). A number of executive departments, such as the Department of Health, Education and Welfare, the Department of Justice, and the Department of Labor, could deal with the changing patterns of information access and associated attitudinal shifts. On issues relating to the financial sector, a number of specialized agencies, such as the Federal Reserve System, the Securities and Exchange Commission, the Federal Communications Commission, and the National Bureau of Standards, could focus on evolving structural and technological changes. In the legislative branch, the Office of Technology Assessment, the Congressional Research Service, and the Government Accounting Office could each assist the Congress in monitoring computer-impact developments on a broad front. In the private sector are a number of foundations, such as the Ford Foundation, the Carnegie Corporation, and the Kettering Foundation, capable of focusing on particular future-oriented social issues stemming from the application of computer-related technologies.

No guarantee, of course, exists that the proposed program will be successful. It could result in another obscure series of reports with little visible effect on the course of events. One of the major hazards of the proposed program is shared by any strategic-planning effort; namely, that the output of the program fails to be coupled effectively to the decision-making processes that it is designed to influence. Thus, neither decisions nor behavior is influenced. And such a hazard is multiplied manyfold in the present context because of the diffuseness of the processes to which the proposed program must be tied. This suggests a need to establish an accompanying program effort aimed at the dissemination and splicing of program outputs to the world of action and the public at large.

Some initial recognition has already been given to these problems by the high priorities assigned to program areas related to achieving computer literacy. But insufficient attention has been given to how such literacy programs are to be implemented. Similarly, only minor consideration has been given to the ways in which the results of monitoring and experimentation programs are to be coupled with legislative processes, licensing procedures, and so forth. What is suggested is the need to develop new instruments for action, such as public sector institutions (e.g., the Office of Technology Assessment) for doing particularized social assessments; ombudsman functions for dealing with policy matters on social impact; and public/private sector organizations (joint government/industry/university) for encompassing and balancing the monitoring, assessment, and dissemination functions. Ultimately, the outcome will be largely determined by the actions and choices of an informed, lay public participating through established political (as citizens) and economic (as consumers) processes. But the timely and systematic generation of information required to create such an informed public is a prerequisite for such action. It is toward this objective that the proposed program is targeted. And, perhaps fittingly, it is to computer-related technologies that society may turn to facilitate the achievement of an increasingly aware and participatory citizenry.

IV. WORKSHOP ON COMPUTER MODELING AND SIMULATION AS AN AID TO DECISION MAKING

A. WORKSHOP PARTICIPANTS

The workshop participants were Roy Amara (chairman), James B. Boulden, Garry D. Brewer, Gary Fromm, Martin Greenberger, Earl B. Hunt, Philip J. Kiviat, Dennis L. Meadows, Richard L. Meier, Walter O. Spofford, Jr., James R. Verougstraete, Willis H. Ware (invited cochairman), George B. Weathersby, and William S. Yamamoto. Appendix B includes biographical information on each of these participants.

B. WORKSHOP SUMMARY

The major theme of this workshop was that the use of computer modeling and simulation is still as much art as it is science.

Little disagreement existed among the participants at the level of basic definitions of *model, simulation,* and *game:* a *model* is any symbolic representation of reality; a *simulation* usually involves the exercising of a model; and a *game* is a model with more than one participant, at least one of which is a human player (implying strategies and competition). Differences in definitions did begin to appear at a more detailed level--on whether all computer models are dynamic by definition, on the distinctions between real games and games of jest, and so forth.

There was almost universal agreement among the participants that the technology (e.g., programming language, computer input/output capabilities, etc.) for computer modeling and simulation in most fields is at least five years ahead of the user's ability to employ this technology. The significant problems are clearly model formulation and model application, rather than model construction. As succinctly put by one participant: "The technology of modeling provides little guidance on what to model or at what level of detail."

The concept of a *model and simulation space* was advanced to clarify points of view on the uses and limitations of models. Physical-science and physical-process models are generally well understood, can usually be validated, and provide outputs that may be readily used by decision makers. To a lesser extent, these features also apply to financial-planning models, econometric models, and some environmental models (e.g., air-dispersion and water-quality models). However, when we turn to urban, regional, ecosystem, and general social-system models, our understanding of basic processes is poor or nonexistent, model validation is seldom attempted, and model outputs should be viewed with great skepticism by model users. In such instances, models and simulations should be used primarily to achieve qualitative understanding of underlying processes of complex systems rather than to produce usable quantitative outputs.

These observations lead to some interesting consequences. Model builders bear a large responsibility for educating users on the limitations of models and for coupling them effectively to the design process. How this coupling might best be done is not at all clear. Most participants rejected as impractical the notion that model users and model builders should eventually merge identities. One interesting suggestion was that perhaps users should be educated in dealing with unvalidated models rather than in developing validation procedures that are likely to prove inadequate. Other suggestions included improving data-base structures and documentation requirements as means for facilitating communication between model builders and users. A final point noted was the almost complete lack of understanding of the factors that determine the extent to which a decision maker uses the outputs of a computer model or simulation.

The theme that computer modeling and simulation are as much art form as science came most forcibly to the surface in the persistent consensus that considerable effort needs to be directed toward retrospective studies of models, modelers, and modeling processes. Although such studies can yield high payoffs in advancing the field, they are not generally done because incentives are lacking for either model builders or users to do them. An ideal area for such initial study is urban/regional modeling, where the required data are publically available, substantial experience exists, and the ratio of successes to failures is small. Although the identification and initial understanding of some of the factors that produce success or failure would be a significant step forward, many of the participants cautioned that useful generalizations could not be drawn from such studies for some time.

This view, in turn, led to several other observations. A key one was that model credibility usually depends more on the identity of the model builder and the output of the model than on model structure. In part, this is because the structure of many useful models depends on the ingenuity of the builder and the "adjustment of parameters or outputs" that he chooses to make. Another observation was that little hope exists at present for developing useful criteria for selecting and educating individuals who are likely to become successful modelers, even though most participants agreed that experimentation to find such criteria and to develop appropriate curricula should be undertaken.

Perhaps the most universally shared viewpoint concerned model validation, specifically, the poor understanding of useful procedures for effecting validation. Virtually all participants agreed that *validation* is the development of measures for increasing (or decreasing) the user's (or builder's) confidence in the utility of the model. Technically, this would involve the application of varying statistical and confidence-limit tests. Operationally--and more importantly--it involves the development of procedures and measures that would lead the user to understand the basis of model design and to compare model outputs to reality. In either case, methods would vary with the kind of model (e.g., statistical vs. alternative-futures vs. world models). Whatever the specific methods ultimately developed, all participants agreed that little or no validation is now done for most social-science models.

It was perhaps this concern with model validation that led to repeated statements of the necessity for finding ways to identify and make more explicit the value orientations of model builders. Clearly, the job of detecting such value orientations is made infinitely more difficult if they become embedded in the internal workings of the model, even though it is recognized that value-free models are a fiction. In a closely related matter, however, most participants rejected the notion that we may be approaching a stage of model development in which a real threat exists that computer-based models may act to "drive" society, rather than the converse.

C. CANDIDATE PROGRAM AREAS

Twelve candidate program areas were culled from the written and oral inputs of the workshop participants. These areas were intended to reflect major issues related to the social impact of computer models and simulations as aids to decision making. Each of the twelve was evaluated with respect to researchability and research priority. Figure 5 displays the candidate program areas in estimated order of increasing research difficulty (i.e., the most researchable appear first).

Retrospective Studies of Models, Modelers, and Modeling Processes

Retrospective studies should be designed to improve general standards and practices in modeling. Those factors that result in success or failure need to be identified and evaluated (e.g., activities that deal with "tuning" or "adjustment" of models, as well as the heuristic learning that takes place with model use). However, some question exists on the extent to which the results of such studies may be generalizable.

In a very pragmatic sense, models may achieve credibility either by being on the "winning side" or by alerting the decision maker (e.g., when using a corporate model) not to take a particular action. But, the state of documentation can also be a very important ingredient in determining model success.

Modeling of Health-Service Systems

The modeling of health-service systems can be a starting point in the development of a general understanding of the delivery of social services in urban environments. Blue Cross and Blue Shield now cover about 100 million subscribers, or almost one-half of the U.S. population, and their records constitute a current census of considerable significance.

Very little modeling is being done in the area of health-service systems. Among the reasons are: (1) hospitals are not generally operated by those sympathetic to such modeling; and (2) federal sources of support are not currently viewing such modeling as a high-priority area.

Figure 5. ASSESSMENT OF CANDIDATE PROGRAM AREAS
(Averaged Overall Rankings)

PROGRAM AREAS	RESEARCHABILITY*	OVERALL PRIORITY RANKING**
1. Retrospective Studies of Models, Modelers and Modeling Processes	1.2	2
2. Modeling of Health-Service Systems	1.2	10
3. Data-Base Requirements for Models	1.3	4
4. Modeling of Personnel Characteristics and Personnel Policies	1.6	12
5. Interface between Model Builders and Model Users	1.7	1
6. Documentation Requirements for Models	1.7	7
7. Role of Group Judgment in Modeling	1.9	5
8. Validation of Computer Models	2.0	3
9. Level of Aggregation in Modeling	2.0	9
10. Identification of Values of Model Builders	2.0	6
11. Selection and Education Criteria for Modelers	2.1	11
12. Interface between Models and Society	2.4	8

*Using a scale of 1 to 3, 1 = most researchable, 2 = moderately researchable, and 3 = least or not researchable.

**Using a ranking of 1 to 12, 1 = most important and 12 = least important.

Data-Base Requirements for Models

Research should be aimed at the development of procedures for achieving a balance between a model (e.g., structure and cost) and its data requirements. Particular attention should be given to the creation of packages of general reformatting and "data-scrubbing" programs that can be used with data bases that are incomplete and fragmentary.

Modeling of Personnel Characteristics and Personnel Policies

The emphasis here is on the development of theories of the individual as a decision maker, permitting probability statements to be made about forecasted performance when faced with particular problem situations. Some initial work is being done by the Armed Forces in connection with personnel assignment and rotation policies. Another objective is to achieve a better understanding of the interaction of individuals in large organizations.

Interface between Model Builders and Model Users

At least two important study areas exist here: (1) the development of more effective ways to couple the varying levels of users of a model to the model-building process; and (2) an analysis of the behavior of a decision maker when confronted with a number of decision-making inputs, one of which is derived from a computer model. Methods used in weighting inputs from several sources to arrive at decisions should also be explored.

Documentation Requirements for Models

This area involves the development of useful standards to define the nature and extent of model documentation required to satisfy the variety of needs of users and builders. This could begin with a standard list of items describing a model: purpose, list of exogenous and endogenous variables and their data-sources, lists of equations, estimation techniques, and so forth. Beyond this, there could be a required index that would allow the user to find his way easily through the documentation. Finally, funding agencies may need an enforced set of review procedures at the conclusion of any modeling effort to assure the existence of adequate model documentation.

Role of Group Judgment in Modeling

Methods for the collection, integration, and incorporation of multidisciplinary inputs from several experts to derive information on model structure and coefficients need to be explored. Considerable emphasis must be placed on the role of modeling as a communication and integration vehicle to help bridge organizational boundaries. Because the use of group judgment in problem solving transcends its application in modeling, it may be that this application should be pursued in conjunction with other efforts for enhancing group communication and problem solving.

Validation of Computer Models

There is an urgent need to develop procedures for judging the degree to which a model resembles the "slice of reality" it purports to represent. This is particularly true for models representing social systems, where there are no well-developed procedures for assessing confidence limits.

The process of validation can sometimes be done by comparing the model with laboratory experiments; sometimes by comparison to test cases that can be handled by other methods; sometimes by comparison to history; and sometimes by comparison with common sense, intuition, or professional judgment. Validation may involve an examination of the structure of the model, the algorithms that are used to solve the mathematics, the computer-program representation of the structure, or the determination of parameters and special output features (including "pathological" cases in which the output behaves unexpectedly). The precision with which validation must be done really hinges on the purpose to which the model is to be put.

It is probable that validation may not be possible except on a case-by-case basis. In any event, only when the validity of a model can be ascertained can sound judgments be made about the utility of its results.

Level of Aggregation in Modeling

The development of systematic rules for determining the appropriate level of aggregation of model variables is a particularly important issue in econometric and social modeling, but exists in some form in all model building.

Some believe that (economic) models should be constructed only at the micro or decision-unit level, while others (because of cost considerations) opt for alternatives that utilize limited aggregation. But aside from cost considerations, (economic) theory and structural specifications are almost always inexact at micro-behavioral levels. Thus, some balance clearly has to be found for matching the level of aggregation to the constraints of data availability and cost.

Identification of Values of Model Builders

Research should be aimed at the development of ways to structure models so that the value framework of the model builder is made as explicit as possible. By examining such values, one should be able to weight their influence on model structure and model outputs.

Selection and Education Criteria for Modelers

This area involves the search for useful criteria to identify those individuals who are most likely to become successful modelers. Although there is some skepticism on the extent to which the search for suitable criteria will be successful, the objective is to determine the set of personal characteristics that correlate with high potential for modeling. Closely related is the question of designing training and education programs that will yield productive and successful model builders.

Interface between Models and Society

The degree to which model construction and behavior act to shape society is not clear. Although the current level of concern over this issue is not high, the increasing scale of activity with social models may bring the issue to this stage more rapidly and subtly than is generally appreciated.

D. SUMMARY AND DISCUSSION OF INVITED PAPERS*

The following synopses of the three papers presented at the workshop include not only the points of view of the authors but also those expressed by others during the discussion.

Computer Modeling and Simulation (Philip J. Kiviat)

- The decade of the 1960s was one of considerable progress in simulation programming and resulted in advances in computer representation, language syntax, and model-support facilities. However, these advances do not help at all in deciding what to model or at what level of aggregation to model.
- Simulation programming languages serve the very useful function of providing building blocks that make it relatively easy for a model builder to construct a simulation model. In fact, since the selection of an appropriate modeling language best suited to a particular task has been made easier, a major step has been taken toward improving the interface between model builder and model user.
- Decision makers should be cautioned to use the outputs of most industrial and defense-related models with great care. Before quantitative results can be used as inputs for decisions, model assumptions and the quality of input data must be understood thoroughly.
- Modeling as a communication process (i.e., in the sense that it provides a vehicle for interaction) may often be more important than the outputs which the model produces. Thus, a model may be invalid as an estimator or predictor but nonetheless prove extremely useful in problem definitions. This is particularly true for social-policy models, where the primary use of modeling should be as an integrating tool to achieve improved qualitative understanding of complex system behavior.
- Modeling is clearly not a turnkey business. It is more an activity or process than a field or science. Accordingly, the ultimate user must be

---

*Full texts of these papers are available from the authors. Copies are also stored in the project files at the Institute for the Future and the National Science Foundation.

involved in the process from the outset if it is to result in a useful product.

- Although model users are becoming increasingly sophisticated, there is a discernible trend away from the use of computer-simulation models in some quarters. Some of this may be ascribed to difficulties experienced in the past due to overblown claims of model builders or misunderstandings of model users.
- The state of the art of modeling technology may be five to ten years ahead of our ability to use it. Therefore, effort in the decade of the 1970s should concentrate on formulating and using models rather than on programming them. Put somewhat differently, the emphasis should be on computer-simulation engineering rather than simulation sciences.
- Major methodological problems centering around the validation of computer models include: (1) the nature of validation; (2) the measurement of validity for different model uses (e.g., observation of system behavior, prediction, and analysis); and (3) the meaning of *statistically valid* data for stochastic models. It is equally as important to educate users on how to deal with incompletely validated models as it is to educate them on how to validate models.
- Some of the principal limitations of modeling stem from the ease with which unexamined assumptions and value orientations can be incorporated in a model and the potential for concentration of knowledge and authority within a small group of specialists and technocrats. Among the possible remedies for overcoming these limitations are: (1) the use of interactive model construction to promote model user-to-model builder and model user-to-model dialog; (2) open and adversarial hearings on model features; and (3) public dissemination of model characteristics.
- In the short run, research is needed on the identification of the important variables of a model, on the training required to produce effective model builders, and on the methods for involving decision makers directly in model construction.
- In the long run, the single most important research problem centers around the interface between the model builder and the model user. Ultimately, perhaps this may be solved by merging the identities of model user and builder.

The Role and Use of Models in the Regional Planning Process (James R. Verougstraete)

- Historically, regional-planning models have tended to focus on population and employment growth, land-use allocation, and transportation facilities.
- Regional population and employment forecasts normally use traditional demographic principles to make forecasts in the twenty- to thirty-year period.
- Land-use-allocation models are generally fairly complex, require large amounts of input data, and permit variation of the time intervals over which the model can be used to forecast.
- Transportation models generally translate population, employment, and land-use forecasts into travel demands by using trip-generation, mode-split, and trip-assignment submodels.
- In the past several years, considerable interest has grown in models centering around environmental issues: air quality; water, sewer, and flood control; and development cost/revenue.
- Air-quality models generally suffer from a lack of accurate historical data (describing air-quality levels over time), which is needed for model calibration and validation. Another problem lies in the translation of the technical outputs of the model into terms understandable by the citizen.
- The basic relationships describing interaction effects in water, sewer, and flood-control models are usually fairly direct and obvious.
- Historical information on the direct and indirect public-investment costs connected with specific development projects is generally lacking. Furthermore, it is very difficult to assess the secondary and higher-order effects of large-scale developments.
- For urban and regional models, computer size is not generally a problem, but input data is. It is often fragmentary, hard to locate, and expensive to collect.
- Staffing a regional-planning activity is a major problem. Generally, it is better to start with planners who can learn to model rather than with programmers or modelers who are interested in planning.

- Elected officials appear generally not to be interested in the details of how models are constructed or work, but only in the ability of models to provide outputs assessing consequences of planning options. Thus, in principle at least, model builders can exploit the model and planning process for personal gain.
- Among the principal uses of regional-planning models are: (1) relating present options to future goals, together with attendant risks; (2) presenting development alternatives that might otherwise not be considered; and (3) providing a basis for preventing undesirable strategies presented by others from being adopted.
- One of the more promising innovations in regional-planning models is the development of a plan-evaluation model to enable private citizens, special interest groups, administrators, and others to interact with the model in the evaluation of alternative development strategies.
- Another important feature of such an interactive model is to provide a forum through which future plans and options can be evaluated against changing social goals. In principle, this would be done by allowing laymen to access planning data bases so that each alternative development strategy may be evaluated vis-á-vis local goals and objectives.
- One explanation for the lack of success with urban- and regional-planning models is the overselling of achievement that has been typical in the past. Until recently, insufficient awareness has existed of the general unavailability of the basic data required to drive a useful model.

Policy Decisions and Economic Models (Gary Fromm)

- The first econometric model describing the structure of the economy was built in the late 1930s. At present, about twenty models of the U.S. economy exist. Far fewer models exist for each of the developed countries, and none exist for most other countries.
- Econometric-model outputs are, and should be, used in decision making.
- Data bases for econometric models are more complete than those for many other social-science models, but even here gaps exist and some data is inaccurate.
- As an illustration of the increase in sophistication of econometric models over the last five years, the number of equations has changed roughly

from 50 to something like 150; and in one particular model, the number of equations is actually 760.

- The practice in econometrics is to make reasonableness checks on the output of the model and to make adjustments directly on the output in order to make the sense of the output jibe with the professional judgment of the person who has built and run the model. However, this procedure has declined markedly in recent years. For example, in the fifty equations that models used in the recent past, perhaps forty of them were adjusted in order to get reasonable solutions. In the corresponding contemporary situation, perhaps only ten are similarly manipulated.
- Practically no work has been done on validation of econometric models; ultimately, each model should perhaps be accompanied by performance data from a battery of statistical tests as a validation index.
- The principal advances made in econometric modeling in the last decade are: (1) the ability to disaggregate at lower levels; (2) a lessening of the necessity to adjust model outputs or parameters; and (3) the extension of forecasts to two- or three-year time horizons.
- The most successful econometric-model-construction efforts have involved team modeling (e.g., the Brookings model).
- Prospects are good for interconnecting econometric modeling to both corporate- and regional-planning models.
- The problem of errors in econometric models is a real one, especially the lack of good statistical and analytical techniques for examining the propagation of errors through large models.
- Significant problems also exist both in communicating with users of econometric models and in attracting potential users of such models. For example, until recent years, the federal government generally paid little attention to outputs of economic models. One significant improvement over the last five years has been an increase in the detail that can be accommodated within a model (this is probably a consequence of much better computing power and improved algorithms to handle the larger systems of equations).
- Research support for econometric modeling should be distributed in priority order as follows: theory building, data collection, and methodology.

E. GUIDELINE QUESTIONS FOR THE WORKSHOP

Computer simulation (both pure process modeling and gaming) which employs human decision making in the model is being looked to increasingly as a tool for the researcher, student, and practitioner in areas as diverse as urban land-use planning and international relations. Its use has been stimulated by the recent development of sophisticated models for analysis of pollution control, land usage, and other important areas of social concern. Its impact has been most directly brought home to the political establishment by the development of global models that sharply challenge certain assumptions and attitudes held dear by much of society.

The social costs of accepting the results of societal models are enormous, yet the potential danger of ignoring them, if they are correct, is even greater. Hence, there is much doubt and hesitance about accepting these models as bases for decisions; and a need exists to establish a rational basis for designing them, evaluating them, and incorporating them into the decision process in such a way that basic social values are not trampled.

The research implied is multidisciplinary and requires understanding of both the technology of system building and the social context in which the system will operate. This workshop represents an initial effort to identify the important questions concerning simulation and define areas of research needed to refine the tool, thus increasing its utility, availability, and comprehensibility to the user.

Questions on Social Impact

1. What effects can or do computer simulation and modeling have on decision-making patterns? Are there data which indicate how equivalent results based on analytical computer models and more conventional mental models are used and interpreted by various classes of decision makers? How important is the mode of presenting the results, and does the presentation tend to dominate over the source of the output data?
2. Several observers have advanced arguments to the effect that computer-based modeling and simulation tend to concentrate decision-making authority in the hands of a few technocrats. Are there obvious

institutional mechanisms which will allow concerned citizens and public-interest groups access to the design, control, and use of such automated tools?

3. How does one go about structuring models so that value-orientation functions are an explicit input which can be identified and evaluated easily?
4. What is our capability, and where are the important research problems, in the area of building better interface systems between computer-based models and nontechnical users?
5. Has any general agreement begun to emerge on the ethical considerations which guide the model designer and user? For example, how should one go about evaluating the need for validation of output against the need to provide an "early warning" of apparent problems? What are the dangers of overselling the field before it has reached an adequate level of accuracy and effectiveness?

Questions on Methodology

1. What is our level of understanding of the procedure of model design, and what research needs to be done to improve the science? There are also technical questions, such as level of aggregation and the selection of modeling language, and system questions, involving the interface between the model builder and the user.
2. What is the state of the art of presenting the results of computer models in a comprehensible way?
3. What procedures do we need to develop to allow validation of a model? This question relates to the stability of computational methods, as well as to the accuracy of the data base, of the relational equations, and of the coefficients in the calculation.

V. WORKSHOP ON COMPUTERS AND FINANCIAL PROCESSES

A. WORKSHOP PARTICIPANTS

The workshop participants were Roy Amara (chairman), Donald G. Barnes, William T. Dentzer, Jr., Herbert Edelhertz, Donald E. Farrar,* Paul E. Giese, Robert C. Hall, Donald P. Jacobs, C. Richard Justice, Alan F. Kay, Neil McKay, J. A. McQuown, Meyer Melnikoff, John R. Meyer (invited cochairman), David H. Morgan, David Novick, Almarin Phillips, and George C. White, Jr. Appendix B includes biographical information on each of these participants.

B. WORKSHOP SUMMARY

Classical notions about industry structure, regulation, and competition in the financial sector must be reexamined and reformulated to reflect the pervasive impact of computer technology on that sector.

Both industry structure and regulation are strongly influenced by computer technology: the number and kinds of firms, the manner in which services provided by such firms are grouped, and the ways in which relative conditions of monopoly or competition exist. For each of the major industries in the financial sector--securities, banking, and insurance--the impact of technology on structure is believed to be very significant, although taking a different form in each case. In the securities industry, the application of technology (aided by pressures from the SEC and from industry self-interest) would very likely result in the creation of a truly central market system linked to a unified clearing and depository system. In the banking industry, the principal structural effects would likely be: continued reduction in the specialization of financial institutions; a reduction in the total number of banks; intensification of competition on both geographic and services bases; and direct access to payment mechanisms by nonbank institutions. Although the insurance industry might be somewhat less affected structurally, the impact on the marketing function would continue to be felt through growth in the variety, range, and individualization of service offerings. In short, technology is acting, and will continue to act, as a major restructuring force in a large part of the financial sector, often creating or stimulating changes that regulatory policy was designed to prevent. More specifically, major points made by the workshop participants (but not necessarily reflecting majority views) include: (1) regulatory policy is generally impeding rather than facilitating change; (2) on the whole, self-regulation has proved to be unworkable; (3) multiple regulators are to be preferred over "regulatory czars"; and (4) in the absence of knowing what regulatory needs may be in the future, increasing reliance should be placed on "free-market" competitive forces to help shape industry structure.

---

*Assisted cochairman in structuring the workshop and in summarizing the sessions of the first day.

Closely related to issues of industry structure and regulation--and strongly influenced by them--are questions of industry centralization and decentralization. Centralization and decentralization may be defined in several senses, but the participants' emphases were on geography and function. Some felt that technology (e.g., minicomputers and data communications) may bring about massive geographic decentralization in the financial-services industry. Others questioned whether such decentralization might not be functional rather than geographic since hardware usually does not represent a major cost of a total system. Perhaps most important was the observation that issues of centralization vs. decentralization can be resolved almost independently of the role of computer technology; that is, since technology is a "neutral" factor with respect to centralization or decentralization, the final choices can be made on other grounds. Such "other grounds" include ease of access to markets, maintenance of a competitive market environment, and the realization of economies of scale.

Considerable skepticism was voiced over the extent to which *real* economies of scale exist in the financial-services sector. An important distinction was made between "unit or component" and "aggregate or end-to-end" scale economies. Unit scale economies are often mistaken for aggregated or actual scale economies. Generally, there is little understanding of the nature of scale economies in dealing with production-function characteristics of a variety of organizations producing a variety of outputs. More specifically, the magnitude of presumed economies of scale used to justify a single, monolithic transfer system in the securities industry was questioned. Real benefits derived from economies of scale must be measured in terms of benefits to industry (production outputs, additional information, or cost savings) or in terms of benefits to consumers (convenience, intangible benefits, and cost savings). At the same time, the point was made that with no firm understanding of the extent to which economies of scale are applicable in an industry, it is best to opt for the marketplace and competition as shapers of industry structure.

Perhaps no topic generated as much heated exchange among workshop participants as standardization within the securities industry. At one extreme, the observation was made that neither standard forms nor standard procedures were necessary, but instead simply "acceptable" forms and procedures falling within broadly defined norms. At the other extreme, standardization was deemed almost synonymous with the continued development of the industry; that is, extensive industry standardization is a necessary precondition to the achievement of needed economies of scale, even though this could also lead to a monolithic (if not monopolistic) industry structure. Somewhere between these extremes, the point was made that standardization need apply only to the communication interfaces of interlinked decentralized or regional systems, thus maintaining a basically competitive and innovative industry environment.

In a very real sense, structure and regulation, centralization vs. decentralization, economies of scale, and standardization represent a set of closely interlinked industry issues that properly occupied the major share of participant attention. Two other important sets of issues also emerged. The first set deals with notions of establishing audit trails, maintaining privacy, controlling preauthorized payments--measures designed to translate component feasibility into system or operational feasibility. However, the key questions revolve around the true system costs for achieving the necessary level of protection against possible abuses in a computerized environment. The second set of issues concern the development of "soft" interfaces between service systems (using computers) and the users or consumers which such systems are designed to serve. Included here are: (1) simple methods for achieving unique personal identification at the input of a service system; (2) the tailoring of personalized service packages; and (3) the humanizing of the "message-exchange" interface between service system and consumer.

C. CANDIDATE PROGRAM AREAS

Nine candidate program areas were culled from the written and oral inputs of the workshop participants. These areas were intended to reflect major issues related to the application of computers in the financial sector. Each of the nine was evaluated with respect to researchability and research priority. Figure 6 displays the candidate program areas in estimated order of increasing research difficulty (i.e., the most researchable appear first). In each case, it should be noted that the focus is the impact of computer technology on that aspect of the financial sector defined by the candidate program area in question.

Economies of Scale

The extent to which economies of scale exist in the financial sector is not known; nor is the manner in which these are being modified by applications of the computer. Study areas should include: (1) a determination of the existence of, and distinctions between, aggregate vs. unit economies of scale; (2) comparisons of large-scale computer systems to minicomputers and communication links; (3) competitive impact of joining trading and post-trading execution systems; (4) the applicability of economies of scale to production-function characteristics of an organization's product/service outputs, and (5) the relationship of economies of scale to industry structure, natural monopolies, and regulatory options.

Retrospective and Comparative Studies

The emphasis here is on the systematic and continuing study of the role of automation in the banking, securities, and insurance industries. Key areas would include: (1) an analysis of the similarities and differences

Figure 6. ASSESSMENT OF CANDIDATE PROGRAM AREAS
(Averaged Overall Rankings)

PROGRAM AREAS	RESEARCH-ABILITY*	OVERALL PRIORITY RANKING**
1. Economies of Scale	1.42	2
2. Retrospective and Comparative Studies	1.45	6
3. Standardization	1.58	3
4. Structure and Regulation	1.75	1
5. Audit Trail, Surveillance, Security, and Fraud	1.82	7
6. Personal Differentiation	1.82	5
7. International System Implications	1.90	8
8. Centralization vs. Decentralization	1.91	4
9. Macroeconomic Effects	2.00	9

*Using a scale of 1 to 3, 1 = most researchable, 2 = moderately researchable, and 3 = least or not researchable.

**Using a ranking of 1 to 12, 1 = most important and 12 = least important.

in approaching automation among the three industry groupings; (2) identification of institutional barriers to automation; (3) technical-diffusion characteristics in transitions from manual to computer processing; (4) the role of the SEC vis-á-vis the role of the FRS in facilitating automation; (5) relationships of technology to competition and industry structure; and (6) the interface of the financial sector with other industrial sectors.

Standardization

The relative merits of technical and operational standardization in the financial sector should be explored from the cost-benefit standpoint. Key areas would include: (1) the purposes, nature, and timing of standards; (2) communication and system/user interface standards; and (3) the relationship of standards to economies of scale, monopolistic tendencies, and interfacing requirements.

Structure and Regulation

Research should be aimed at analysis of the relationship of industry structure to regulation in the financial sector and the ways in which this structure (and its relationship to regulation) may be modified by the application of computer technology. Study areas should include: (1) the relative growth of integrated or specialized services; (2) the impacts of new services and repackaging of old services on industry structure; (3) the regulatory implications of the technological innovations; and (4) marketing and distribution systems of financial intermediaries, particularly economies of cross-selling services.

Audit Trail, Surveillance, Security, and Fraud

Potential computer-related abuses created by the increasing automation of the financial sector need to be identified and analyzed. Key study areas include: (1) the economics of audit-trail implementation; (2) the development of new sets of pattern indicators to detect abuses; and (3) the relationship of surveillance methods and standardization choices.

Personal Differentiation

The whole range of issues dealing with individualization of automated systems needs to be explored. Study areas should include: (1) the feasibility of input-identification systems; (2) opportunities for tailoring services to individual needs; and (3) the humanization of the interface between consumer and computer system.

International System Implications

An investigation of the international implications of automation would require retrospective and comparative studies of foreign systems, standards and market interfaces, and surveillance issues.

Centralization vs. Decentralization

The focus here should be on investigation of the competing tendencies for centralization and decentralization and the role technology may play in this competition. Key areas would include: (1) centralization of decision making vs. centralization of services; (2) geographic vs. functional centralization; and (3) the relationship of industry structure to competition, diversification opportunities, and specialization or integration of services.

Macroeconomic Effects

The emphasis here is on the study of the indirect impacts of computer technology on the financial sector and the ultimate effects on monetary policies, capital formation, savings, and investment.

D. PANEL REPORTS

The first day of the workshop was structured around three major themes: organization of securities markets; clearing mechanisms for banking and securities industries; and provision of financial products and services. Corresponding to each theme, a panel of three participants was designated prior to the workshop to prepare and present points of view on critical policy issues related to computer impact. The proceedings of these presentations as well as the reactions of the other participants are summarized below.

Organization of Securities Markets (C. Richard Justice, Robert C. Hall, and Alan F. Kay)

C. Richard Justice

- The National Association of Securities Dealers Automated Quotation System (NASDAQ) resulted from a combination of the following circumstances: (1) the desire of the SEC to improve communications and disclosure in OTC trading markets; (2) the availability of technology; (3) the self-interest of securities firms in reducing costs and improving customer acceptance of securities traded in these markets; and (4) the existence of an organizational framework provided by NASD.
- Major impacts on OTC trading markets have resulted from the reduction in communication costs made possible by NASDAQ. Some major New York trading houses have lost their former dominance as market makers in OTC stocks while regional firms have been strengthened; and large wire houses have taken advantage of increased interest in OTC markets by strengthening their market-making operations.
- The wider dissemination of bid/ask quotes produced by NASDAQ has (1) narrowed spreads, (2) improved information, (3) improved surveillance, and (4) generally improved the quality of secondary trading markets in OTC securities.
- Three of the circumstances that are necessary for the creation of a central market system for trading listed securities now exist: (1) pressure by the SEC; (2) available technology; and (3) interest of non-NYSE-member firms in obtaining nondiscriminatory access to a "central marketplace". However, the final ingredient (corresponding to NASD for OTC) does not exist since the NYSE does not represent an appropriate organizational framework.
- Strong, opposing private interests would be affected by proposals to create an open central market system. Third-market dealers and non-exchange-member firms stand to benefit from the creation of the system; exchange specialists, the NYSE, and regional exchanges as operational entities are all threatened by the proposed creation of the system. Some participants felt that (in the evolution of a central market system) regional exchanges would evolve toward the provision of pure

service-bureau functions. At the same time a single regulatory framework would emerge with the creation of a single, nationwide trading market for listed securities.

- Computer-based communications activities have been automated with the least resistance in the securities industry, because such activities operate in support of selling. On the other hand, the traditional lack of interest in back-office operations has impeded the intelligent application of computers to these operations.
- The effect of automating back offices will be to replace such in-house functions with shared services, such as those provided by the National Clearing Corporation. This will result in improvement of the competitive position of small- and medium-sized firms.
- Some debate occurred over whether large firms would benefit more or less than small firms from reduced communications and data-processing costs. It was argued that the substitution of fixed costs for variable labor costs in very small firms might increase rather than reduce their total clearing costs. On the other hand, this would result in continually decreasing unit costs for larger-scale operations, thereby benefiting the larger firms.
- A single depository and a single clearing system are expected to develop in the securities industry as a result of continually increasing economies of scale for these functions. In addition, increased fixed costs resulting from the introduction of computers are likely to aggravate existing problems faced by the industry in terms of the extreme volatility of its revenues. This would likely encourage further efforts within the industry to reduce revenue and earnings volatility through diversification into other activities.
- Revenue and earnings volatility requires greater permanence of capital; thus, profits from prosperous years must be retained to finance lower earnings or losses during succeeding years.

Robert C. Hall

- The securities industry is far behind other industries in the applications of computers (with the possible exception of NASDAQ and some back-office operations). The industry is now on the threshold of major changes due to a combination of regulatory and cost pressures.

- The principal developments that may result from the application of computer and communications technologies are: (1) a central market system with a number of regional inputs; (2) a single depository system; (3) tight coupling between trading processes and depository functions; (4) "locked-in" trade; and (5) man/machine interface on both sides of the trade. One-day settlement of securities transactions may be possible in less than five years.
- A central trade-reporting system may some day collect and report all trade data and trigger the post-trade clearance process. Obstructions to the development of such systems are not technological, but rather political or private interest in nature.
- The development of a totally automated trading system may lead to a purely dealer market. In addition the survival of the auction market could require protection in the form of priority that would be accorded limit orders by individual investors over dealers trading for their own accounts.
- Automation will not replace humans in the market system because of the requirement to sense market shifts and to assume risks.
- No important changes in the profile of functions performed by securities firms are visualized except that there could be greater emphasis on service than on mechanical functions.
- Among the important issues or problems related to automation are: (1) the creation of audit trails within automated systems; (2) the development of input devices to permit the movement of data more quickly; and (3) the development of standards that would result in reduced operating costs while at the same time maintaining opportunities for the development of competitive, innovative systems. On this last point, there was some difference of opinion on the role of economies of scale in forcing a somewhat monopolistic structure to develop.

Alan F. Kay

- Autex is a private communications network dealing with block-trading information for the institutional trader. Its design is premised on the philosophy that the securities industry must consider its services from the point at which the existence of an order is speculative or uncertain rather than when the order is in hand.

- The principal item transmitted through Autex is an "interest message". Approximately one in thirty interest messages results in a trade. Autex currently accounts for an average of one million shares per day.
- As Autex has grown, new features have been added. Post-trade confirmations, screening features, and an ability to recall historical data have been added to the system since it began operation. New markets such as bond trading have been added; and a lumber-inventory trading system is planned for the near future.
- Autex and NASDAQ currently serve two quite different markets, though either could, with modifications, perform many of the functions now offered by the other. Autex, offering greater flexibility, tends to deal with trades where negotiation is desired prior to execution. NASDAQ, with lower retrieval times and more highly formatted quotations, focuses on the higher volume of small-order transactions in OTC markets. Principal areas of interface are where brokers enter messages through Autex on both sides of the market.

Discussion

- The issue of standardization was examined at great length. On one hand, standardization is often used as a wedge for exclusivity. Standardization is permissible for communication processes at interfaces (particularly for physical systems), but standardization is not required elsewhere. On the other hand, standardization may be necessary for making progress in the industry, and the inherent economies of scale resulting from increased automation may lead to the development of a monopolistic structure.
- The question of the future roles of exchanges in a central market system was also raised. Exchanges will continue to exist to perform self-regulatory and trading functions. Furthermore, the trading floor could coexist with electronic trading systems because of efficiencies in verbal communication and because such market makers could compete effectively with off-floor market makers, operating through electronic communication and trading systems.

- The market system itself should create the structure of the securities market. Both technology and tax laws have forced moves toward a "free" market.
- The question of the relationship between the organization of the U.S. securities market and international markets was also raised. At present there are no interfaces (and therefore no traffic) between such systems.

Clearance Mechanisms for Banking and Securities Industries (William T. Dentzer, Jr., David H. Morgan, and George C. White, Jr.

William T. Dentzer, Jr.

- The Central Certificate Service (CCS) has changed its name to the Depository Trust Company (DTC) and the new corporation will have membership in the Federal Reserve System as a limited-purpose trust company. DTC is embarked on an effort to expand its services outside New York City and to offer them in a nondiscriminatory manner, not just to brokers but to banks, insurance companies, investment companies, and other financial institutions.
- In the present context, the clearance function is defined to include the following principal functions: (1) corroboration of the existence of a trade; (2) netting down trades to achieve efficient settlements; (3) delivery of securities; and (4) related payment of funds.
- A National Depository System could be developed conceptually in any of three ways: (1) as a federally created and operated system; (2) by expanding one existing depository into a national system; or (3) by recognizing the existence of regional depositories linked into a national system. Although either the first or second option might benefit from economies of scale, economic and regional rivalries would probably impede the development of any but the third option.
- DTC envisions the use of a network of regional banks as input centers for its system in all areas except California and Chicago, where regional depositories already exist.
- DTC will become a nonprofit mutual organization. It is financed by a schedule of charges for its use. Current charges are based on per-share

activity, and future prices will be more related to the cost of providing each service.

- Beyond insurable risks the credit problem for DTC is self-insured within the depository's membership. The depository guarantees the credit of each member in daily settlements; and failures would be covered by assessments on members.
- Other forces at work within the securities industry may lead to some increase in concentration. However, the depository function per se should be neutral, by insisting that its membership be open to all qualified institutions and broker dealers, and that its pricing structure be constructed carefully to insure that no class of member is treated preferentially.
- Other benefits resulting from automating the clearance and settlement process are that record keeping would become more standardized and would be improved overall.

David H. Morgan

- Alternative clearing methods include: (1) trade for trade with dollar settlement; (2) trade for trade, net, with dollar settlement daily; (3) daily net, deliver balance order (with and without depository); and (4) continuous net settlement, with and without depository. The trade-completion process as outlined, includes customer, floor, clearing, and depository functions (including transfer), in a variety of different sequences and configurations.
- The National Clearing Corporation (NCC) was founded in 1969 in the midst of Wall Street's "fails crisis" to provide a national clearance system for OTC stocks.
- A relationship may be developing between the proposed central market system, composite tape, communications system, and nationwide trade-completion process, that will permit trades in exchange markets to be settled directly from the point of trade reporting, into a depository environment. However, because so many securities in the OTC market are in short supply to depositories, many of them would continue to be cleared outside a depository environment. These trades could be completed in the

future through continuous net settlement, in NCC or other automated clearance systems. Where depositories cannot be used, bank-transfer agents would continue to play a role in the trade-completion process. The system necessarily will remain labor intensive as long as securities must be handled physically.

- It was reported that 75 percent of the NCC system computer time currently is used for clearance, and 25 percent for regulatory surveillance and control. The proportion devoted to surveillance and control is growing and would continue to do so, to the benefit of improved disclosure and regulation in securities markets.
- Regional exchanges operate NCC points of entry into the system on a "facilities-management" basis. The system now is being tied into NASDAQ, which will permit direct interface between NASDAQ and depositories such as DTC.
- Proposed legislation emerging from House and Senate Securities Subcommittees will increase federal control over the clearance process. The House version envisions vesting control over clearing agencies and depositories exclusively with the SEC; the Senate version envisions responsibility over clearing corporations vesting with the SEC and over depositories vesting with the FRB. The Securities Industry Association has recommended that competition be taken out of the clearing organizations. The SIA recommends that all these organizations be replaced by a single National Clearing System.

George C. White, Jr.

- The volume of bank stock-transfer transactions has dropped as a result of growth in the availability and use of "jumbo" certificates and securities depositories. Decreased volume has led banks (which had often regarded transfer as a peripheral activity) to reevaluate and improve their own transfer operations. By using the transfer-agent depository (TAD) concept, bank-transfer agents can approach the efficiency offered by depositories in the transfer function for large institutional holdings. The TAD concept is used by Merrill Lynch with large transfer agents. A large balance or jumbo certificate is used to make transfers as directed by Merrill Lynch, and new balance positions are determined daily by the transfer agent. The First National Bank of Boston is experimenting with the TAD concept for individual stockholders.

- The principal emphasis in bank applications of automated systems, however, is on the development of electronic-transfers capability using standard formats. Examples are the COPE system in Atlanta and the SCOPE operation in California. A Bankwire system, which is being operated by a consortium of over 230 banks for large money transfers, may be modified for disbursing high-volume transactions such as dividends, payroll, annuities, and so forth. In New York City, the Automated Clearing House System or CHIPS (Clearing House Interbank Payments System) transfers funds between banks for international transactions and is being upgraded with a new computer switch to include other types of payments.
- Awareness of problems in the development of paperless funds-transfer processes is growing, such as format and procedural standardization. The New York system has standardized its transfers on funds valued the next day, rather than on the day of transfer and settles approximately $50 billion daily.
- The question was raised of whether electronic funds transfer or the "checkless society" appeared to be emerging more rapidly in the area of disbursement of credits than in the collection of funds. As an example, the Air Force experiment with the Federal Reserve Board was noted, wherein the Air Force payrolls are deposited directly by wire in the employees' personal checking accounts, without the intervening use of the checks. Examples on the payment or debit side included the combination of Consolidated Edison with New York Telephone bills for simplified billing and collection to achieve savings in bill-preparation expenses.
- Customers more readily forego their control over the timing of payments by check in exchange for the convenience of paperless transactions, where such payments are contractually fixed (as for mortgage payments) than they do for department store or other more variable charge accounts.
- A comment was made on the duplication of credit-card systems developed separately by banks, rather than by integrating credit-card operations with an already existing, highly efficient check-processing system. If credit cards had evolved in the form of "overdraft banking" rather than

as parallel and apparently separate systems, the result would have been more a variation of check-processing capability than a completely independent system.

Included here is a summary of some observations made in a luncheon address by Mr. Donald G. Barnes on the role of the Federal Reserve System in banking automation.

- The FRS Steering Committee on Improving the Payment Mechanism took the necessary initiatives to move toward automation of clearance mechanisms based on the realization that the growing volume of checks would become increasingly costly to handle and that competition for labor would become increasingly difficult.
- The following historical developments are related to increasing automation: the establishment of RCPC's (Regional Check-Processing Centers), SCOPE, the Atlanta EFT Study, Automatic Clearing Houses, and the use of preauthorized debits.
- The FRS has recently been petitioned by the Air Force to distribute its payroll checks directly to offices around the country. This is likely to be followed by similar requests from the Army, Navy, Treasury, Social Security Administration, and so forth.
- In the role of wholesaler or intermediary for member banks, the FRS has also been petitioned recently to provide a POS (point-of-sale) mechanism for the exchange of debits and credits among banks.
- Some thinking is also taking place about the international aspects of bank clearing through SWIFT (Society for Worldwide Interbank Financial Telecommunications).
- The consumer is becoming increasingly sophisticated in terms of his demand for improved services in banking. Competitive pressures generated may eventually result in a significant reduction of the total number of banks from the present 14,000.
- The FRS will probably provide the facility for a single, integrated national payment system to which regional networks would be connected.
- Fewer distinctions will exist among presently different financial institutions.

- Even with the expected growth of electronic funds transfers, checks and currency will most likely be in use for a long time to come.

New Products and Services (Neil McKay, J. A. McQuown, and Meyer Melnikoff)

Neil McKay

- The recent reduction in specialization of financial institutions is expected to continue, as traditional bank markets feel greater competition from other institutional types. Increased customer sophistication also heightens competitive pressures on banks, and the banking industry's ability to compete directly for customers' funds with other institutional types is impeded seriously by Regulation Q, prohibitions on the payment of interest on demand deposits, and Glass-Stegall restrictions on access to other investment vehicles.
- A transition to one-statement, and even one-account, banking may be a means of accommodating competitive pressures.
- One area in which paperless transfer systems are growing, however, involves large disbursements from one financial institution to another. In addition to COPE, SCOPE, and Bankwire systems, two new electronic payment-authorization systems are now beginning operation. The expansion of credit cards to larger purchases formerly financed by installment credit (such as automobiles and major appliances) also is envisioned in the near future.
- Some banks have evidenced interest in cards that access checking accounts directly, perhaps carrying overdraft privileges. This possibility is slowed, however, by customer reluctance to give up control over the timing of payments, obtained through traditional check and passbook vehicles for transferring funds. Should Justice Department opposition to shared-input facilities be withdrawn, paperless POS systems could develop quite rapidly in retailing. Such systems would, of course, encounter the usual range of problems over the sharing of development and operating costs among participating banks.

- Banks will find it increasingly less important to satisfy the location-convenience function; computer technology will substitute automation convenience for geographic convenience.
- As electronic funds-transfer systems are developed, demand by nonbank thrift institutions for direct access to the payments mechanism is inevitable, thus further reducing differences between traditional, specialized depository institutions.

J. A. McQuown

- The banking industry has traditionally been poor in marketing its services but rich in the applications of technology, whereas the opposite is true for the securities industry. In both cases, the major automation issues deal with the interfacing of computers to humans.
- Most financial institutions are arbitrary partitions of economic behavior or are primarily outgrowths of government regulation. The institutionalization of economic behavior tends to increase resistance to change--largely as a result of regulatory goals and inflexibility, which tends to impound both the technology and accepted ways of doing business at the time that regulations are instituted. As a result, positive economic benefits to be obtained from change must be large to overcome resistance to changes in traditional ways of doing business. For example, note the obstacles in developing efficient systems for clearing securities transactions in the face of comparisons between the cost of performing essentially similar functions in banking: costs of check clearing are estimated at ten cents per transaction, while estimates of the cost of transferring securities are estimated as being two orders of magnitude greater.
- The capacity for change clearly requires at least one degree of freedom. But, more specialization to achieve greater efficiencies reduces the degrees of freedom and therefore the adaptability and the prospect for change. This effect is further reinforced by the impact of regulation that further reinforces the move to institutional specialization, thus further reducing the prospect for change.
- The magnitude of presumed economies of scale used to justify a single, monolithic funds-transfer system in the securities industry was questioned.

The cost of communicating between alternative systems should be sufficiently low to permit the development of competing, interlinked regional or other systems, which would provide benefits anticipated from nationwide systems without conferring monopolistic privileges on a single system or eliminating incentives to adapt to changed economic forces or technological opportunities.

- Technology (e.g., minicomputers and data communications) may bring about massive decentralization of the financial-services industry. Some question was raised whether such decentralization might not be functional rather than geographic since hardware costs usually do not represent the major costs of a total system.
- Very few intrinsic differences exist among the banking, securities, and insurance industries. Their current products or services may be designated as risk-free assets, risky assets, and time assets, respectively. But these institutional partitions fly in the face of the fact that consumers demand all three, and they are mutually dependent, especially in marketing economics. Thus, the marketing of services represents the most serious problem area faced by financial institutions.
- An important advantage conferred by technology is that it provides a means of building bridges around regulations and other vested interests that tend to inhibit change. As a result, the computer is expected to be a powerful agent for change, by eliminating barriers between traditionally specialized institutional types.

Meyer Melnikoff

- Technology and the breakdown of regulatory barriers around traditional types of institutions do not necessarily lead to reduction in the eventual degree of specialization by institutions in the provision of financial services. Some incentives toward financial integration can be traced to regulatory constructs (such as regulated prices), and functional specialization does provide considerable economies. Also, centralization need not be geographic in character; and it may often be dictated by access to particular data bases rather than by geography.

- Economies of scale in life insurance derive strongly from the industry's distribution system. With the exception of small numbers of highly specialized men working in narrow but affluent markets, salesmen equipped with multiple products generally tend to be more productive (if the products are complementary in nature) than the single-product salesmen.
- The major impact of the computer in the insurance industry thus far has been in administrative operations and service to policyholders rather than in marketing, although that too has been affected. In some areas, the computer has made possible the provision of a range of individualized, responsive, and flexible products, a trend that is expected to accelerate with the advent of variable life insurance, and extensions of mass marketing. The computer has undoubtedly been a major force stimulating change in the industry as a whole.
- Pressures from Washington for pension reform will probably have major impacts on the future form of the pension business. It is believed that the trend may be toward packages such as TIAA-CREF, which are standardized but incorporate many degrees of freedom that may be exercised by individual employees, at their option.
- The problem of retaining an audit trail in real-time, interactive computer environments is exceedingly serious, and often economically infeasible with existing technology. Some dissent on this point was expressed by noting that, although satisfactory audit trails are expensive to provide, they are not technologically infeasible at present. As evidence, note was made of the Air Force's Logistics Management System, the NYSE transaction system, and an automated accounting system developed for a major Swiss bank. There was agreement, however, that such systems are exceedingly expensive to develop, operate, and maintain.
- Further problems related to automation include: (1) the risks of designing systems that appear dehumanizing to the consumer; and (2) the difficulties of providing customer identification at the input to real-time systems.
- Large-system interdependence might render entire systems vulnerable to breakdown from the collapse of a single component. Breakdown of a major accounting or funds-transfer system could paralyze an entire

institution, perhaps over a considerable period of time, which in turn could impact on other institutions and an entire market or industry with a domino-like effect.

E. PREINTEGRATION CRITIQUES (HERBERT EDELHERTZ, PAUL E. GIESE, DONALD P. JACOBS, DAVID NOVICK, AND ALMARIN PHILLIPS)

The purposes of the preintegration critiques were: (1) to extend, amplify, and add to the range of issues which surfaced on the first day of the workshop; and (2) to begin the process of focusing on specific candidate program areas.

Herbert Edelhertz

- The concept of industry self-regulation is basically unsound. It is essentially a defense used against externally imposed regulation. It is unlikely that the self-regulatory process will produce data useful to regulatory agencies.
- Consideration should be given to the possible division of regulatory functions on a horizontal rather than a vertical hierarchical basis.
- Even relatively small frauds can produce large magnifier effects on the industry affected.
- Suspicion was registered about the notion of computers checking on other computers with the complete absence of human intervention or surveillance.
- Opportunities for fraud are growing (e.g., medical and dental payment systems and perpetual inventories). Attention should be paid to payment mechanisms outside the financial sector as well as within it.
- In the absence of knowing what the nature of regulatory needs may be in the future, the fostering of as much competition as possible is the best hedge against possible abuses.
- Other areas that deserve attention are: (1) the problems of working across extended time zones and the possibilities of a twenty-four-hour market; (2) the possible use of computer models for evaluating alternative regulatory options; and (3) the relative merits of a single regulator (rather than multiple regulatory jurisdictions) for an entire industry.

Paul E. Giese

- The technological components for automating the financial sector are generally available, or can be shortly. Progress still needs to be made in the following areas: (1) identification systems (thumb prints, voice prints, and so forth); (2) storage devices for massive random access; (3) specialized terminal costs; and (4) the reliability of automatic reading devices for printing and handwriting. Although hardware costs will continue downward, software costs will probably remain relatively high but are more difficult to forecast.
- System feasibility, with its associated considerations (e.g., ensuring privacy, back-up and reliability costs, conversion problems, and so forth), is not as readily assured, however, as the individual-component feasibility noted above.
- Audit-trail problems can be handled with computerized systems. The real questions revolve around the true costs of providing such audit trails.
- The issue of centralization vs. decentralization can be resolved almost independently of the role of computer technology. Technology can support either equally well; the final choice can thus be made on other grounds.
- The FRS was able to play a facilitating role in banking automation because of its direct involvement in operations and its established credibility.
- Skepticism was expressed about the existence of real economies of scale in the financial-services industry. For example, the use of service bureaus for processing may not be more efficient in the aggregate since there may be loss in control and loss in flexibility. Both the macro (industry-wide requirements for a system) and the micro aspects of the industry must be considered. At the macro level, one may have little choice. At the micro level, the economies of scale for local/regional cooperative ventures are unpredictible and their potential must be balanced against the risk of loss of control and flexibility and increasing processing costs.
- Benefits of economies of scale must be measured in terms of benefits to

industry--production outputs, additional information, and cost savings--or in terms of benefits to consumers--convenience, intangible benefits, and cost savings.

Donald P. Jacobs

- The impact of regulation on the financial-services industry is real. Regulation could affect industry structure if the manner in which computer technology is to be applied were known.
- With no firm understanding of the extent to which economies of scale are applicable in the industry, it is best to opt for the marketplace and competition as shapers of industry structure.
- In the banking industry, the role of economies of scale diminishes considerably for banks with deposits in excess of $10 to $15 million.
- Location of small banks will be diminished by automation, by bringing big banks into remote areas.
- A massive restructuring of the banking industry, which regulatory policy was designed to stop, will take place.
- A definition of *good social policy* was proposed: economies of scale that are allowed to operate in an industry if competition exists.
- More regulators are better than fewer regulators since adaptation to change takes place more easily with the former than with the latter. In any event, the establishment of a regulatory czar should be avoided.
- Self-regulation does not work; if regulation is needed at all, it must be imposed externally.
- The "squeaky-wheel" analogy usually applies in the formulation of regulatory policy.

David Novick

- The bond market does not need the application of computer technology; the "used-equity" market clearly does. The representation function, as opposed to the trading and completion-of-trade functions, accounts for the major expenditure in the securities industry.
- Computers can be an important element in the policing of the securities-trading process.

- It is a mistake to think the securities industry needs standard forms or procedures for efficient operation; instead, the need is only for *acceptable* forms and procedures.
- The most important problems in the financial-services industry do not involve keeping track of securities or creating a checkless society. Rather, in the securities industry, the most important problem involves the ability to handle "breakout" conditions and to improve the liquidity of the market.

Almarin Phillips

- The potential for the application of computer technology in the financial-services industry is great.
- The principal inertial elements are regulators, vested interests, organizational resistance, and consumer resistance.
- EFT will come faster than any of us believe.
- The FRS deserves considerable credit for facilitating change in the banking industry; however, the regulatory part of FRS is not on top of the changes taking place.
- The literature on the diffusion of innovation may be important in focusing retrospective studies of the financial-services industry.

F. GUIDELINE QUESTIONS FOR THE WORKSHOP

1. Many have argued that the development of large, computer-based fiscal and monetary systems are creating significant institutional changes.
    - To what extent, and how, has the computer been an agent in the evolution of markets, services, and institutions in the securities, banking, insurance, and credit-handling sectors?
    - How is this likely to change?
    - Has computer technology acted to stimulate or to inhibit change?
    - What principal institutional constraints are operating to inhibit desirable change in sectors of interest?
    - How do these constraints operate?
    - How is the situation likely to develop in the next five to ten years?

2. Answers to the foregoing questions may point to the research required to encourage the orderly development and diffusion of modern technology in the financial sector. Should such research be aimed at:
   - the development and application of specific computer technologies?
   - the analysis of particular economic, financial, and regulatory processes?
   - the understanding of the problems at the interface of computer development and financial processes?
3. Significant institutional and social impacts may result from the changes in processing time associated with advanced computerization.
   - Have (or will) such changes in processing times brought on by automated systems significantly altered the power structure associated with marketing and service institutions in the securities, banking, insurance, and credit-handling sectors?
   - Have (or could) such changes resulted in any more general realignment of power blocs outside the general area of the fiscal and monetary sectors?
4. A number of social and regulatory issues are raised by the emergence of large, automated financial systems.
   - From the viewpoint of the citizen user, how has computer-based technology changed the complexity of his interactions with financial institutions?
   - What are the short-term trends likely to be in this area?
   - Are they subject to easy modification?
5. As automated systems grow in complexity, the task of accurately tracing or reconstructing many of the transactions for security, audit, or regulatory purposes has grown increasingly difficult.
   - What is a proper characterization of the current state of this problem?
   - What is the scenario if current trends are projected?
   - Are there potential hardware or software solutions to problems in this area?

6. Vast quantities of data on individual and corporate financial transactions will exist in machine-readable form.

   - Are technical capabilities in control accessibility progressing rapidly?

   - Which institutional variables will promote or retard the implementation of appropriate safeguards to privacy?

VI. WORKSHOP ON COMPUTER PERCEPTIONS, ATTITUDES, AND LITERACY

A. WORKSHOP PARTICIPANTS

The workshop participants were Roy Amara (chairman), Ronald E. Anderson, Robert L. Ashenhurst, Philip M. Burgess, Walter M. Carlson (invited cochairman), Joel W. Goldstein, Harry T. Larson, Dwaine Marvick, Robert Nathans, Sally Yeates Sedelow, William D. Smith, Percy H. Tannenbaum, Irene Taviss, and Thomas White. Appendix B includes biographical information on each of these participants.

B. WORKSHOP SUMMARY

The principal issue of this workshop centered on ensuring the widest possible *individual choice* for those whose lives are touched or affected by information systems.

Five principal purposes for research and collection of data on computer perceptions were defined first: (1) to provide inputs to public-policy making; (2) to understand social-change processes; (3) to structure suitable programs of education and training; (4) to provide inputs to system-design processes; and (5) to help assure the effective use of computer technology.

A wide variety of data on computer perceptions, attitudes, and behavior should be collected. The primary objective of these efforts is to provide inputs for the structuring of education and training programs and to lay the groundwork for understanding the relationships between computer technology and social change. General agreement existed among the participants on the necessity to develop a set of periodically updated baseline data in a form that is more disaggregated than exists at present. Included in a suggested list are: (1) public perceptions of what an information system is; (2) the uses to which it can and cannot be put; (3) who designs it; (4) the purposes it serves; (5) how accessible it is for inspection; and (6) how modifiable it is. Also included would be (7) public perceptions and attitudes on the definition of *privacy, confidentiality, freedom of* *information, think,* and *human;* (8) perceptions and attitudes of computer scientists and policy makers toward the development of computer technology; (9) assessment of differential gaps created by computer technology between "haves" and "have nots", as well as between those who possess and those who are without computer sophistication; and (10) behavioral changes resulting from information systems, as evidenced by somatic effects and the impacts on self-definition and self-esteem, on work and leisure patterns, on problem-solving capability, and on citizenship. In short, a directed program of data collection would achieve, as an ideal, the construction of a cognitive map of the similarities and differences in perceptions and behavior among the principal groups in contact with computers. This is clearly a long-term goal and must be tempered by methodological and budgetary constraints.

Methodological questions center around the validity of measurements of perceptions, attitudes, and behavior. Considerable care must be exercised in imputing attitudes from perceptions and, more importantly, in assuming a causal relationship between attitudes and behavior. Where the relationship between attitudes and behavior is relatively clear, the measurement of attitudes may be acceptable; in other cases, behavior and behavioral changes must be dealt with directly--sometimes a more difficult task. The workshop participants disagreed on the proper allocation of efforts among surveys, case studies, and longitudinal studies. Some concern was expressed that insufficient effort is being placed on case studies aimed at understanding the basic processes of perception and change, as opposed to surveys where measurement can be done more easily. Most agreed that longitudinal studies are necessary to provide accurate data on both attitudinal and behavioral changes. Another area deemed worthy of exploration was the possible use of some judgmental (as opposed to quantitative) measures in tracking perceptions and attitudes. Perhaps one of the more important notions advanced was that general measurements of public attitudes and perceptions of computers should not be undertaken in isolation, but rather as part of a more comprehensive program to monitor public attitudes on technology and technological change.

Parallel to, and supported by, a program of research on computer perceptions, attitudes, and behavior is research on a number of issues related to public policy. The most important issues are those related to the impact of information systems on institutional goals: (1) conflicts in institutional goals created by the application of the computer (e.g., efficiency vs. privacy); (2) individual options for coping with computer-related job displacement; (3) the computer and the forces influencing social uniformity or diversity; and (4) computer-technology assessment as a part of a larger national effort to anticipate the secondary and higher-order effects of technology. Difficult as these issues may be from the standpoint of researchability, they rank highest in research significance.

Equally as difficult--and reinforcing the major workshop theme--is research on the development of humane or responsive design criteria. The individual must, first of all, be considered as integral with the information system from the very beginning. Greater emphasis must be placed on the detailed analysis of the requirements to be met to fit an information system into the environment in which it will operate. A deeper understanding must be achieved of substitutes for "human niceties and social rituals" in an information-system context, as well as of those characteristics that are intrinsic in a human being's makeup. *Humanizing* has a different meaning at each level at which an information system is to be made responsive to the needs of an affected group. In all of this, simple exhortations about responsive systems to system designers will not suffice; public-policy guidance must be developed, buttressed ideally by a discerning and literate public (or consumer).

Computer literacy stands in sharp contrast to the preceding sets of issues. Not only is computer literacy relatively easy to define, but once widespread literacy is accepted as a desirable social goal, then the structure and content of comprehensive programs for achieving literacy from grade-school to college levels and beyond can be readily designed. One problem stems from the absence of any natural societal advocates for computer literacy--although professional computer societies may play a role here. Another difficulty may result from the long delays--probably five to ten years--and, consequently, the long lead times that are operative before the effects of any literacy program will be felt. It should be noted that the goal of achieving increasing computer literacy is not to forestall possible conflicts in computer use but rather to raise the level of computer awareness so that users may exploit computer systems more fully and protect themselves from possible abuses.

C. CANDIDATE PROGRAM AREAS

Seven candidate program areas were culled from the written and oral inputs of the workshop participants. In the assessment, each program area was first played against each of the five purposes for research defined in the summary of this workshop; relevant intersections were then ranked in terms of research priority. At the same time, each area was evaluated with respect to researchability. The results are shown in Figure 7, with the candidate program areas arranged in increasing order of research difficulty. The entries in this figure were generated as follows.

- An overall assessment was first made by the workshop participants of the program areas that would contribute most significantly to the achievement of the research purposes. Thus, on a column-by-column basis, particular cells were checked (without rankings) in terms of the relevance of the program area in contributing to the indicated research objectives.

- A cross-check was then made by the workshop participants by reading along each row to modify (by adding to) the list of cells identified in the earlier step. At the conclusion of this part of the assessment, twenty-two of the possible thirty-five cells were singled out for closer evaluation.

- Each participant was asked to rank the checked cells in terms of research importance, selecting only the top ten of the twenty-two. At the same time, each area (or row) was to be rated with respect to researchability (1 = most researchable; 2 = moderately researchable; 3 = least or not researchable).

The numbers entered in the twenty-two cells of the matrix in Figure 7 are the averaged workshop rankings; the numbers in the right-most column are the averaged ratings of researchability for each candidate program area.

Requirements for Computer Literacy

The establishment of objectives and programs for achieving an understanding of basic computer functions at a variety of societal and educational levels.

Figure 7. ASSESSMENT OF CANDIDATE PROGRAM AREAS
(Overall Rankings*)

Program Areas / Purposes	Research Importance**					Researchability***
	Public Policy	Social Change	Education and Training	System Design	Effective Use	
1. Literary Requirements	6		3		16	1.2
2. Perceptions and Attitudes		7	4		12	1.6
3. Role of Media		17	20		22	1.7
4. Institutional Operations	14	13		15	19	1.9
5. Institutional Goals	1	8		21		1.9
6. Humane Design Criteria	2			11	18	2.1
7. Behavioral Changes	9	5		10		2.1

*Numbers (1 to 22) within each cell designate the aggregated participant ranking in terms of research importance. Differences in closely adjacent rankings should not be considered significant. Numbers in right hand column designate the aggregated participant ranking in terms of researchability.

**1 = most important, 22 = least important.

***1 = most researchable, 3 = least researchable.

Inventory of Computer Perceptions and Attitudes

The development of a continuously updated data base on computer perceptions and attitudes of individuals and groups as these are influenced by present and anticipated uses of the computer.

The Media and Computer Technology

An investigation of the role of the mass, organizational, and informal media in developing understanding of the impact of computer technology on society.

Impact of Information Systems on Institutional Operations

The study of the ways in which the application of information systems serves to modify work patterns, delivery of services, sharing of data bases, and so forth.

Impact of Information Systems on Institutional Goals

The study of the ways in which the application of information systems serves to modify institutional objectives and purposes.

Humane Design Criteria for Information Systems

The identification and incorporation of information-system features that ensure responsiveness of such systems to the widest possible range of individual choices.

Impact of Information Systems on Behavior

The tracking of changes in individual and group behavior resulting from interaction with information systems.

D. SUMMARY AND DISCUSSION OF INVITED PAPERS*

The following synopses of the four papers presented at the workshop include not only the points of view of the authors but also those expressed by others during the discussions.

---

*Full texts of these papers are available from the authors. Copies are also stored in the project files at the Institute for the Future and the National Science Foundation.

The Problem of Computer Literacy (Robert L. Ashenhurst)

- The determinants of contrasting attitudes toward computers must be explored before an appropriate approach to the problem of computer literacy can be formulated.
- Because attitudes are conditioned by perceptions, one must first characterize perceptions.
- A clear distinction must be made between computer systems (the computer and its associated hardware) and information systems (the totality of the information-processing and decision-making environment within which the computer is imbedded). This distinction is of critical importance in addressing issues of computer perceptions, attitudes, and literacy.
- The present state of knowledge of public perceptions of computers is generally inaccurate and grossly oversimplified. Measurements of such perceptions do not adequately convey the dichotomy that exists in the minds of most people concerning the positive and negative aspects of computer (and information) systems.
- Since most people do not work directly with computers, most perceptions and attitudes about computers are based on experience with information systems in which the computer is only an element.
- Computers are viewed variously as inanimate objects, pets, or persons--depending on circumstances. Perceptions of computers in this sense have not been studied carefully, if at all.
- An interesting context in which to study the formation of attitudes concerning computers is the Apollo Space Program, where many TV viewers received similar inputs about computer applications.
- In the long run, a major need exists to develop more elaborate models of what perceptions of computer systems are, how they are formed, and the manner of tracking them.
- Most information systems are designed without sufficient attention to the information-analysis phase (as contrasted to the more technically

oriented system-design phase). What requirements must be met to fit an information system into the environment in which it will operate?

- Lack of knowledge about information systems prevents the public from understanding how to assign responsibilities for system malfunction.
- There is a growing danger that some computer supersystems (mainly military applications) will surpass the user's ability to understand them.
- The individual must be considered integral to the information system from the outset; most information-retrieval systems have not proved successful because the user was largely excluded in the development of the system concept. Two aspects of this problem that are of overriding importance are: the integration of the individual and his needs into the system design in an anticipatory fashion (i.e., in terms of the likely future conditions and requirements to be met); and the integration of the individual and his needs into the design of very large information systems, where the effects that can be produced by complex systems are very poorly understood.
- Information systems will continue to be designed and applied in inhuman ways unless public pressure increases; and this requires increased public computer literacy.
- Computer literacy may be defined as the ability of a specialist in a certain activity to discern which aspects of that activity can be computerized readily and which cannot.
- Computer perceptions and attitudes often depict man's private hopes and fears rather than any external reality.

First Progress Report on an Inventory of Research Measuring Perception of Computerization (Ronald E. Anderson)

- Generally, the data on perceptions of computer technology are very uneven, research methods are poor, and most results are neither very interesting nor illuminating.
- The following studies and activities are noteworthy as better than average efforts: Robert D. Hess and Maria Tenezakis, *The Computer as a Socializing Agent: Some Socio-affective Outcomes of CAI*, Technology Report No. 13, Center for Research and Development in Teaching, School of Education, Stanford University (October 1970); Todd LaPorte and Daniel

Metlay, *The Watch and Wonder, The Public's Attitudes toward Technology: A Survey*, Working Paper No. 6, Institute of Governmental Studies, University of California at Berkeley (1973); and the ongoing monitoring by the Educational Testing Services of the Mitre Ticcit and the University of Illinois Plato Systems.

- Studies of selected cartoons on computers in magazines of the past twenty-five to thirty years can provide useful clues on changing perceptions of computer technology.
- Some evidence exists that children grasp the real significance of cartoons at a fairly early age. Moreover, much of what is written about computer technology in the popular press does not necessarily reflect what an author thinks about computers, but rather what he feels will attract the attention of his readers. However, one should not overrate the influence of such representations until studies of their real impact have been made.

The Impact of Computerization in Los Angeles: 1973; Some Sample Survey Differentials in Perceptions and Attitudes (Dwaine Marvick)

- A shared-time omnibus survey was described which included questions on: (1) the incidence and kinds of personal problems linked to computers; (2) computer experience on the job or in job training; (3) computer automation; (4) the use of computers in government decision making; and (5) receptivity to computerization in medical and educational contexts.
- Although the data collected from the survey has not yet been completely processed, it is already clear that participation in an ongoing omnibus survey can yield significant returns. As an example, the survey permitted the author to work closely with other survey investigators in relating responses to some of the computer-related questions to psychological constructs dealing with loci of control and alienation measures.
- Research assessments should examine the impact of increased familiarity with computers on the effectiveness with which individuals solve problems.
- Any serious effort to acquire information on computer perceptions, attitudes, and behavior must include longitudinal studies that will shed

light on how individuals adjust to their work environments over time.

- Case studies (and surveys) on perceptions and attitudes should be performed in order to derive a better understanding of the basic processes involved and to permit more focused measurement efforts.

Some Thoughts on the Questions for the Workshop (Irene Taviss)

- Much of the work on computer perceptions and attitudes has the flavor of "data for data's sake". It appears that little forethought has been given to the extent to which computers may be producing changes in the ends, purposes, and objectives of organizations.
- Insufficient attention is being given to the meaning of *humanizing* by those who design and build information systems that are purportedly matched to individual needs at various levels (e.g., managers, employees, consumers, and so forth).
- Widespread computer literacy will not necessarily solve most problems related to computer perceptions.
- There are inherent conflicts between producers and consumers of computer technology. Although such conflicts are not necessarily bad, those that are based on misconceptions should be identified (e.g., as from the AFIPS-Time survey) and corrected.
- The goals of computer scientists and the kinds of systems they are planning, as well as the more global impacts of computers on the structure of society, must be identified.

E. PANEL REPORTS

Four panels were formed midway through the first day of the workshop to address specific sets of issues that arose during the presentation and discussion of invited papers. These panels dealt with: (1) measurement of perceptions, attitudes, and social change; (2) the meaning and implementation of computer literacy; (3) humane design criteria for information systems; and (4) public-policy issues raised by computerization.

Measurement (Thomas White*, Murray A. Aborn**, Ronald E. Anderson, and Joel W. Goldstein)

- Measurements of computer perceptions and attitudes must serve as inputs for making public-policy choices, for understanding social change, for education and training, and the like. The basic problems here are not simply those of measurement, but also those of anticipating and forecasting the impact of future computer technology.
- Any program of measurement should explore the possible uses of social indicators and media-content analysis. Also, measures of computer perceptions and attitudes should include some totally judgmental aspects, as well as some involving quantifiable indicators.
- It is unlikely that we will be able to justify the development of social indicators to be used solely for tracking computer technology. More realistically, we should look for indirect measures that could yield data on attitudes toward information systems (e.g., shifting employment patterns, disputes over privacy, and frequency of billing errors).
- One of the most important problems in measurement is validity. The extent to which perceptions are good indicators of attitudes is not at all clear; nor is the cause/effect relationship between attitudes and behavior. In instances where the relationship between attitudes and behavior *is* clear, attitudes can be the focus of measurement; otherwise, we must attempt to measure behavior and behavioral changes directly.
- As the computer progressively becomes submerged in the information system in which it is a component, it may indeed gradually lose its identity as a focus for perceptions and attitudes.
- A thorough data-collection effort should include:
    - an assessment of public perception of what an information system is, the uses to which it can be put, the uses to which it cannot be put, who designs it, the purposes it serves, how accessible it is for inspection, how modifiable it is, and so forth;
    - an assessment of the influence of computer technology on public attitudes toward privacy, confidentiality, isolation, job satisfaction, and so forth;

---

*Lead panelist.

**National Science Foundation observer.

  - an assessment of the perceptions, attitudes, and behavior of both computer scientists and policy makers regarding the development and uses of computer technology;
  - an assessment of the extent to which, and how, information systems serve to increase the differential gap between "haves" and "have nots", both in terms of access to computers and degree of computer sophistication; and
  - assessments of the gap between those at the leading edge of computer technology and others in society.

- It would be desirable to imbed a measurement of perceptions of computer technology in a broader assessment of technology in general. In other words, general measurements of public attitudes and perceptions of computers (as contrasted with the more narrowly defined measurements undertaken to provide input to specific system-design activities) should not be made in isolation.

Literacy (William D. Smith[*], Dwaine Marvick, M. Granger Morgan[**], and Sally Yeates Sedelow)

- The achievement of computer literacy is, in itself, intrinsically good since computer technology is here to stay. *Computer literacy* is defined as the understanding of basic computer functions in terms of what computers can and cannot do, with particular attention to their potential, as well as their limits, in meeting human needs.
- Achievement of widespread computer literacy may be considered a form of consumer education designed to produce the essential feedback for providing quality control on the design and application of information systems.
- The results of a program to achieve widespread computer literacy would likely not be felt for five to ten years. Eventually, it may be desirable to develop a form of computer-literacy test.
- Data are required on the nature of computer courses presently offered at the grade-school, high-school, and college levels. Some observations made about requirements at each of these levels include the following:

---

[*] Lead panelist.

[**] National Science Foundation observer.

- *Grade School.* Useful material can be made available directly from the new math or can be adapted from it. Any good introduction to computers should include some "hands-on" time with computers so that direct experiences can be obtained about the nature of program (logic) errors. More importantly, it allows the beginner to experience success or failure with computers in an immediate, direct, and closed-form manner. At the same time, it would not be too early to introduce the novice to some notion of how information systems are designed and the nature of their social impact.

- *High School.* At this level, current instructional material is either not very good or is nonexistent. Courses need to be designed for all students--not just the college-bound group. They should convey information on the present and potential social impact of the computer, as well as its technical and operational features. There is a need for a curriculum package (serving both this level and the introductory college level) that would provide "hands-on" workbook activities or games containing instruction on systems design, economic and service trade-offs, and so forth, drawn from nontechnical real-world settings. Special note was made of the implications to teacher training for carrying out such programs.

- *College.* A basic instructional unit at the freshman level should provide as direct and active experience as possible with the computer. Such a course should not fall into the "computer-appreciation" category, but should be organized so as to draw students together from a variety of disciplines. A desirable level of achievement is that a student from any major field of study be made fully cognizant of the state of the art of computer-processing capabilities in his field.

- Although no specific requirements for adult and continuing education were proposed, it was noted that job discrimination in some sectors may be based increasingly on computer illiteracy. High-school-level courses may be adapted to meet on-the-job training needs. Also noted was the almost complete lack of a suitable TV series on the nature and uses of computers, much like the ABC news series, "On the Side of Man", shown in the early months of 1973.

Humane Design Criteria (Harry T. Larson*, Robert L. Ashenhurst, and Fred W. Weingarten**)

- Many, if not most, people who have contact with an information (or computer) system feel that such systems are inhumane. (Although a precise definition of *inhumane* was not given, *lack of responsiveness in meeting individual needs* and *incapability of responding to the exercise of individual choice* may be used synonymously with the term.)

---

*Lead panelist.

**National Science Foundation observer.

- Before progress can be made in developing humane design criteria, the roles of the principal groups interfacing with computer systems must be identified and humaneness must be translated into operational terms vis-á-vis each role group.
- The following is an illustration of a possible taxonomy of groups:
    - users (e.g., middle-level managers, time-sharing-system customers, and mission-control operators);
    - developers (e.g., system architects, analysts, and programmers);
    - maintenance personnel (e.g., staff responsible for system modifications);
    - computer operators (e.g., staff operating at consoles or handling tapes, disks, cards, and so forth); and
    - consumers (e.g., individuals interacting directly with the output of an information system).
- To illustrate how the notion of *humaneness* might be translated into operational terms for one role-group category, the following preliminary requirements were generated for the *consumer* group:
    - access to scrupulously accurate information;
    - ability to exercise individual choice on the matter of membership in a consumer group;
    - access to information about oneself and availability of a reasonable means for changing it;
    - ease of implementing changes, with corroborating feedback of the changes made;
    - ability to disapprove, with some limitations, of certain uses of personal information;
    - access to a system interface which has features of individuality, including the use of names instead of symbols, words instead of codes, and explanations of alternatives instead of listing of options;

  - access to system safeguards against incomplete information (e.g., arrest and disposition), as well as against use of obsolete data (e.g., file-purge rules); and
  - access to prompt, clear, and accurate explanations when failures do occur.

- Several research tasks were identified:
  - an in-depth exploration of the roles of those affected by computerized information systems (expanding greatly on the taxonomy noted earlier);
  - a detailed study of the concerns and complaints expressed by consumer-group members, the relation of these to characteristics of real computerized systems, and the structuring of remedial action programs to be undertaken to achieve operational humaneness; and
  - an investigation designed to translate humaneness into operational terms for other role groups (in more depth than was shown for the *consumer* group) and the definition of an action program aimed at meeting the requirements for humanization of information systems for each group.

Public-Policy Issues (Percy H. Tannenbaum*, Robert Nathans, and Irene Taviss)

- *Computer vs. Human Interface*. The displacement by a computer system of a function previously performed by a human may produce desirable benefits, but the interface is almost always incomplete in some human sense--personal rituals and niceties are lost. Although an impression of a two-way communication channel between the consumer and the system may be created, in fact, the interface responds more like a one-way channel, in a seemingly impersonal manner.
- *The Computer and Social-Goal Conflicts*. The efficiency achieved by the application of computer technology often raises conflicts between the basic social objectives of preserving privacy of personal information and exercising freedom of choice in personal matters. The exercise of individual choice by those affected by an information system is perhaps the overriding principle around which such conflicts must eventually be resolved.

---

*Lead panelist.

- *The Computer and Job Displacement.* Insufficient attention is being directed to job displacement and work-pattern shifts created by computers. Although society as a whole may benefit from such changes, each individual is affected differentially and is often without options for early retirement, job retraining, use of leisure time, and the like.
- *The Computer and Social Uniformity.* The extent to which the application of the computer is contributing to the creation of a more uniform social environment is not understood. Even though the computer creates the potential for less uniformity, society appears to be failing to exercise its options for diversity. To some extent, the issue of centralization may be closely tied to uniformity.
- *Computer Technology ssessment.* As part of a growing national effort to understand and harness technology more effectively, information technology will come under closer social scrutiny. Among the possible developments are: (1) requirements for information-system licensing arrangements; (2) the preparation of information-system impact statements; (3) publicly supported analysis designed to identify and assess higher-order effects and provide early warning of proposed information-system applications; and (4) growing professionalization of the field of information-system design and application.

F. GUIDELINE QUESTIONS FOR THE WORKSHOP

1. What have we learned from previous measurements of public attitudes toward and perceptions of computers and computer-based systems? In what way, if at all, has this knowledge been important or useful?
2. Should further measurements of public attitudes and perceptions be made? If so, what data are needed to complete a set of baseline data for future comparative studies? What type of future measurements are important, and why? Will national data suffice for most purposes, or are regional and/or local data essential? Is it reasonable to think in terms of supporting only a single umbrella survey in which a number of investigators participate together, or are separate, individual data-gathering efforts essential?

3. It has been argued that the design of systems which are not to be perceived by users as dehumanizing should be undertaken by the creative efforts of sensitive, innovative, and perceptive designers, rather than through major social-science measurement efforts. Is this a valid assumption?
4. Can *computer literacy* be defined with reference to *public literacy regarding the computer*?
5. What types of activities are essential to a high level of public literacy? How should they be undertaken, and by whom?
6. If a high level of public literacy is achieved, how will the attitudes within, and structure of, the computer-science technical community change?
7. How is the application of the computer influencing the paradigms that society develops and uses? What indicators can be used to monitor changes?
8. What inhibiting effects, if any, do computer perceptions have on individual behavior? What can be done to minimize such effects? What indicators might be used here?
9. Is there any evidence to support the belief that computer literacy produces a more realistic outlook toward the role of the computer in society?
10. How do we minimize the possible confusion between the roles of computer educator and computer popularizer or lobbyist?
11. What programs of research in this general area make sense for the National Science Foundation (and others) in the next five to ten years? How effective are such programs likely to be in influencing perceptions and literacy? How can these be related to other possible efforts (e.g., the Office of Technology Assessment) aimed at achieving a better understanding of the potential impacts of specific technologies on society?

VII. WORKSHOP ON COMPUTERS AND INDIVIDUAL ACCESS

A. WORKSHOP PARTICIPANTS

The workshop participants were Roy Amara (chairman), Michael A. Baker, Robert P. Bigelow, Ithiel de Sola Pool, Michael A. Duggan, Hope Eastman, Robert Kling, David B. H. Martin, Daniel D. McCracken, Lee L. Selwyn, Thomas B. Sheridan, Frederick B. Thompson, Joseph Weizenbaum, and Marshall H. Whithed. Appendix B includes biographical information on each of these participants.

B. WORKSHOP SUMMARY

The dominant sense of this workshop was that even the most rudimentary data on behavioral changes ascribable to computer access are essentially nonexistent.

Computer access may be defined in several ways. In the very broadest sense, it is essentially synonymous with *rationalization of societal processes,* and the research problems become as intractable as those for technology-initiated assessments.* In the simplest terms, the workshop participants saw computer access as the ability to use the services of an information system either directly or indirectly, much in the same sense as one uses (or accesses) a telephone system, a transportation system, or a public library. However, this definition had to be brought into focus before the real problems of access could be broached. Distinctions had to be made between access to information about oneself, access to nonpersonal information, and access to computer and communication facilities. Other useful dimensions included: (1) the accessing entity (e.g., individual, social group, institution, or government); (2) the nature of the obstacles to access (e.g., lack of skills or unavailability of software); and (3) the

---

*National Academy of Engineering, Committee on Public Engineering Policy, *A Study of Technology Assessment*, Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969).

immediacy of access (e.g., raw computing to an indirect service). In fact, the clarification of the meaning of *access* was one of the significant problems that the workshop participants unavoidably had to face. No attempt was made to combine the differing bases of access into a single framework or taxonomy; rather, in most instances either the sense in which the term was being used was sufficiently clear from context, or the simple definition noted earlier was used.

The central problems of computer access are clearly not technology-related; rather, they lie at the relatively neglected interface of the human and the information system. Critical issues include: (1) the development of adequate standards to handle the proliferation of hardware development; (2) the trade-offs between the expertise required to gain access and the technological/economic burden that can be placed on the system itself; (3) the role of natural languages in facilitating human-to-machine communication; and (4) the proper balance to be struck between centralization and decentralization in the design of information systems.

The degree of centralization is directly affected by a host of largely unresearched areas, including the structure, economics, and regulation of the mass information-services market. No clear-cut indications exist on whether the information-services industry will develop along the CATV model or the video cassette/disk model, or what the relative roles of the cable and telephone systems may be. What is clear is that public or individual access to information services will be determined largely by the manner in which costs for such services are allocated. The key issues thus deal with: (1) the extent to which natural-monopoly considerations apply (probably not at all); (2) the feasibility of achieving universal access through competition (one possibility would be subsidies taken from community tax bases); and (3) the nature of the demand and supply functions for information services. Our state of knowledge on the demand side is much too rudimentary at present; and on the supply side, we need to explore the bundling of information services and alternatives for reshaping classical industry lines (e.g., publishers, newspapers, broadcasters, and so forth). The extent to which experience from other countries can provide clues on opportunities for horizontal integration is also an important question.

Politically, it is naive to think that computer access for particular social groups can result in any significant redistribution of power. At most, such access could serve to eliminate an excuse for *not* redistributing or sharing political power. Perhaps the key point here is that public access to information systems should include the ability to monitor and control the development of such systems. Thus, a fairly ambitious program of retrospective studies and monitoring efforts should be pursued. This is not to say that efforts aimed at providing increased citizen access should not be supported and encouraged, for there is some evidence that citizen efficacy may thereby be enhanced. However, the workshop participants viewed such efforts as peripheral, if not wasteful, particularly if they lead to a climate of "instant referenda".

From a legal standpoint, computer access is intimately related to privacy, confidentiality, and security. Perhaps the core issue here is the possible inhibiting effects on individual behavior resulting from increased societal access to personal information. Unfortunately, virtually no data exist to permit more than speculation about the extent and severity of the possible effects.

The most pervasive issues and impacts related to computer access are believed to stem from perceptual change, paradigm shifts, and contextual effects. Not surprisingly, these are also the most difficult to research. Of primary concern here are the ways in which access to, and contact with, computer systems serve to affect or shape one's image of the world. A search for answers might include a whole array of matched-group experiments in which the objective would be to detect differences in perceptions, decision-making procedures used, performance measures selected, and so forth. We should also explore the ways in which the application of the computer acts as a force both for fractionating society (by producing contextual changes) and for stabilizing society (by facilitating communication).

The workshop participants were unable to agree on whether computer access will contribute to increased societal diversity or not and, more importantly, the extent to which this may be desirable. In particular, great concern was expressed about the potential use of computers to proliferate trivial product differences under the guise of individuality. Perhaps the only long-term hope for coping with some of these fundamental issues is the initiation of specific programs for achieving widespread computer literacy--at the grade-school, junior-high, and high-school levels. Whether, in fact, such programs can raise literacy levels in time to forestall the undesirable societal consequences ascribable to increasing computer access is an open question.

C. CANDIDATE PROGRAM AREAS

Ten candidate program areas were culled from the written and oral inputs of the workshop participants. These were intended to reflect major issues related to the social impact of computer access. The participants did not favor the use of rank-order correlations or other quantitative measures of preference ordering.

Retrospective, Comparative, and Case Studies of Access

Research should be devoted to a systematic review of computer-system applications to assess their impacts (e.g., skill levels required and style of information used) on system designers, managers, and users, as well as on the public at large. Included in the range of investigations are: (1) transitions from manual to computerized systems; (2) the impacts of increased access on keepers of information systems; (3) the relationship of access to social control; and (4) comparative analyses of access using international systems (e.g., Swedish income tax) as referrants.

Monitoring of Information Systems under Development

The emphasis here should be on the collection of data on major information systems in various stages of development and implementation to provide an early-warning or technology-assessment function on present and anticipated consequences. Included in this monitoring should be data on how far each system has progressed, what each purports to do, and possible unanticipated consequences--in short, the creation of a guidebook to large information systems.

Inhibitory Effects of Access

Measuring mechanisms need to be developed, and experiments must be designed for collecting data on the possible behavioral effects of increasing availability of personal information. The range of explorations might include detection of behavioral changes arising from: (1) the operation of the Bank Secrecy Act (e.g., incidence of transactions under $5,000); (2) records on political activity of particular social groups; and (3) the nature of medical records keeping (e.g., extent of quantitative vs. subjective data used).

Access and Literacy Requirements

Increasing computer access imposes new educational requirements on society. Research should be aimed at methods for achieving these needs. Included should be: (1) the content and manner of teaching computer skills to grade-school children; (2) the feasibility of using computer-networking arrangements at junior-high and high-school levels; (3) methods for conveying accurate descriptions of computer capabilities and limitations; and (4) the promotion of concern and understanding among designers of the needs of the information user.

Access and Large Data Bases

The accessibility or inaccessibility of large data bases should be studied from the standpoints of: (1) setup costs; (2) maintainability; (3) retrieval characteristics, including the effect of performing a variety of statistical manipulations easily; (4) idiosyncratic features; and (5) degree of data-base coupling and networking.

Access and Interface Requirements

Research should be aimed at an assessment of the principal technological and economic barriers to increased access, including: (1) technological developments and standardization; (2) costs and pricing policies; (3) skill requirements; (4) use of intermediaries; and (5) expertise required vs. cost trade-offs.

Regulatory and Competitive Dimensions of Access

Structural factors within the information-services industry (including natural monopoly, centralization vs. decentralization, and vertical integration) need to be analyzed in terms of their influence on intraindustry competition and access. Included should be: (1) retrospective analyses of regulatory developments in the communication and computer industries; (2) the relevance of natural-monopoly considerations; (3) legal barriers to access; and (4) a definition of *public record*.

Access and the Organization of the Information-Services Industry

The emphasis here is on the study of interindustry structural factors, including bases of organization, ownership patterns, and horizontal integration. Included should be: (1) forecasts of the demand for augmented or new services; (2) an evaluation of alternative methods for restructuring classical industry lines; (3) an examination of the economics of service-bundling systems; and (4) comparative analyses of international systems.

Conflict between the Right to Know and Personal Privacy in Information-System Design

Research should be aimed at the development of basic principles with which to balance the conflicting requirements of access and privacy. Included here should be: (1) the development of operational definitions and taxonomies of access and privacy; (2) the structuring of generic case studies of conflict; (3) the identification of anomalies and inconsistencies; and (4) comparative analyses of international systems.

Social Shaping of Reality via Information Systems

The emphasis here is on the design of experiments for understanding the manner in which contact and experience with information systems affects one's image of the world. Included might be: (1) experiments designed to detect and evaluate behavioral differences resulting from various information-access environments; (2) matched-group experiments (e.g., differences in perceptions between computer-science majors and humanities majors, differences in decision-making procedures between managers who rely on "management information systems" and those who do not, and so forth); and (3) a study of the impact of access on the selection of measures of system performance, particularly whether sophisticated and quantitative measures drawn from operationally oriented data bases become the intellectual currency for decision making and policy debate.

D. SUMMARY AND DISCUSSION OF INVITED PAPERS*

The following synopses of the four papers presented at the workshop include not only the points of view of the authors but also those expressed by others during the discussions.

Computers and Contextual Change (Frederick B. Thompson)

- The computer can act in two opposing ways on society: first, as a fractionating agent, since it is a powerful force for stimulating conceptual change, and second, as a stabilizing agent, since it is also a force for facilitating and encouraging communication. It is the interplay of these two forces that should provide the focus for any research on the social impact of the computer.
  - Which contextual (or conceptual) cleavages should be bridged and which should be retained? We need to understand on a case-by-case basis how the application of the computer may trade individual and societal diversity for institutional efficiencies.
  - How and where can computers be applied to modulate the rate of contextual change? We need to understand how the very processes of data collection and processing affect the groups under study.
  - How can experience with computers themselves be utilized to increase tolerance for contextual change? The bottleneck is neither technology (which is clearly furthest advanced) nor software; it is rather the area of the interface (e.g., natural languages and special application devices) between user and information system that can have the most profound effects on access to, and acceptance of, the computer as an instrument for contextual change.

---

*Full texts of these papers are available from the authors. Copies are also stored in the project files at the Institute for the Future and the National Science Foundation.

- Information is becoming increasingly idiosyncratic as we computerize data bases along narrow, discipline-oriented fields. In a very real sense, the narrower we make the data base, the less accessible we make it; but this is not altogether undesirable, for this stresses the subjective nature of information and the plurality of approaches. Two opposing trends are seen:
  - the development of smaller, decentralized, interactive computer systems using natural-language inputs that make for less transferability from one system to another; and
  - enforced commonality through the networking of facilities and a narrowing of the diversity of resources that are available, with the result that some creative research will be inhibited.
- The issue of centralization vs. decentralization of computer facilities (or efficiency vs. access) is arising increasingly with respect to computer-systems planning in less developed countries.
- The drive toward forced conformity is fairly widespread in both the public (e.g., ARPA, NSF, and EDUCOM) and private sectors (e.g., IBM), where the prevailing assumption is that information is to be treated as a commodity.
- Standardization will probably not play a role in moderating the conflict between conformity and creativity, since standardization can create the illusion of the communicability of information. By the same token, diversity may be an illusion, because the highest-level transformation routines provide an upper bound to transferability since all transformations result in some loss of information.
- Economics will dictate the growth in the use of natural languages. Simply put, given a limited supply and productivity of programmers and the expected growth in computer systems, we will be forced to develop languages which will yield a great deal more computing per statement and which will permit more people to have direct contact with computing systems.

Information Technology and Individual Access: Some Economic and Regulatory Considerations (Lee L. Selwyn)

- Here we are dealing primarily with access by the mass information-services market rather than with access by researchers and other highly sophisticated users.
- Perhaps the experience in the telecommunications industry (particularly with the common carrier) can provide some useful guidance on the development of the information-services industry. For example, like communications carriers, portions of the information industry can be characterized by natural monopolies (created by economies of scale), where regulation is used as a substitute for competition. Although such conditions may exist in only certain sectors (e.g., distribution), vertical integration with sectors which are characterized by more normal production characteristics could eventually extend monopoly status to the entire industry.
- Public and individual access to information services will be determined largely by the manner in which costs for such services are allocated among consumers, advertisers, and other participants in the marketplace.
- Cost allocation and rate structuring are infinitely more difficult in the information-services area than in the utility-services area, where the services provided are fairly homogeneous in nature (e.g., electricity, gas, and water).
- One important issue within the mass information-services industry is the level at which regulatory authority ought to reside. If regulation is at too high a level of government, local access to services may be inhibited; if regulation is at too low a level, the inadvertent adoption of unnecessarily restrictive policies may prevent widespread access.
- Competition can coexist with a policy of encouraging universal access, provided that industry subsidies come from the community's general tax base rather than from particular classes of customers (e.g., low-cost service).
- It is very likely that some combination of both local and remote computing will play a role in providing information services to the home. This raises the question of the extent to which the industry will develop along the CATV model or along the video cassette/disk model.

- A major area of technological competition is cable systems vs. the telephone network. The outcome will depend on many factors, not the least of which is the rapidity with which the cable system can provide new services (other than over-the-air broadcasting).
- The development of interface standards among the wide variety of system-access devices will be among the most important elements of public-policy formulation.
- The human-interface area will continue to be the most important bottleneck in direct consumer access to computing and information systems for at least the next decade. To some extent, the exact length of time will depend on whether we are dealing with computer systems or computer-aided systems and on what level of complexity the interaction with the human is to be.
- In many respects, the economic and technological characteristics of computer-based information services are quite different from those of broadcast television. For example, with computer-based services, the consumer can be highly selective; metering is a natural by-product of the service; quality of service depends critically on the skill of the consumer; and service origination costs are more modest.
- There are very few data on the potential nature, size, and economics of the information-services market. However, it is clear that the economics of services to the home will be influenced greatly by service bundling and by technological developments in other areas (e.g., electronic mail by post office).

Political Aspects of Access to Computerized Record Systems and Computing Facilities (Michael A. Baker)

- Among the conclusions of the NAS study of computer data banks are: (1) for political and economic reasons, many computer-system projects that might pose information-access problems have been slowed down; and (2) although computer systems generally make information services faster and cheaper, it is difficult to identify larger social impacts.
- We should undertake a broad program of experimentation aimed at collecting basic data on access (and nonaccess) to specific kinds of information,

including patients' access to their own medical records and expunction of arrest-only records.

- Care must be exercised to guard against the creation of false impressions about the degree of control made available to citizen groups or employees.
- Three distinct kinds of access should be considered.
    - *Access to Information about Oneself.* This includes a knowledge of what files exist; the ability to see one's own record; and the ability to correct or challenge a record about oneself.
    - *Access to Nonpersonal Information.* This includes performance and planning data, allowing for some selective withholding of vitally secret data. Confidentiality and access goals will often conflict here.
    - *Access to Computer and Communication Facilities.* This includes organizational arrangements under which individuals are provided indirect access to information services.
- Public access to computer systems should include the ability to monitor and control their development.
- In view of the inherent difficulties of successfully forecasting the potential social impact of computer technology, the best one can do is to put efforts into monitoring computer-system developments and applications. Such efforts might identify: (1) data systems being created; (2) the functions they are to perform; (3) the stage of development; and (4) the extent of their current social impact.
- The medical records-keeping area is one in which it is difficult to detect changes created by computerization. But this may be misleading, for real changes are often *not* revealed by discontinuous breaks with the past. Among the possible effects of computers in this area are wider availability of data on service characteristics, on physician "profiles", and on costs.
- In addition, computerization increases: (1) the ease of record duplication; (2) the ease of record accessibility due to security failures or lapses; and (3) the ease of record writing.
- At least two different classes of access difficulties should be considered.
    - The lack of expertise of the potential user group often precludes access and use (e.g., Sierra Club and EPA data base).

- The lack of the requisite software methodology often precludes access and use (e.g., citizen access to urban/regional models).

- Retrospective studies of computer applications may well indicate that the computer is not always as indispensible a system element as it appears to be. For example, although it may seem that we could not operate as a nation without the degree of centralization present today, in fact perhaps regionalization might have been successfully effected without computerization. Thus, retrospective evaluations of information systems should be careful to consider, where possible, the alternative paths that might have been taken, since computer-based information processing is typically one alternative among many.

Computers and Individual Access: Legal/Judicial Aspects (Michael A. Duggan)

- The value of a data base often depends more on who may be excluded from using it than who may access it.
- The high capital or initial cost and relatively low maintenance or reproductive cost associated with some data bases has led some to ascribe a natural-monopoly function to information utilities.
- Differential access to the data bases employed in judicial/legal contexts may already be occurring. This may include access to data banks on: (1) the backgrounds of prospective jury members; (2) the sentencing proclivities of individual judges; (3) jury verdicts for various types of physical and mental injuries; and (4) panels of expert witnesses. Differential access is a by-product of the way information is disseminated--i.e., more on an ability-to-pay than a need-to-know basis.
- Hard data on the inhibitory effects of data bases on personal behavior is nonexistent. Furthermore, it is not at all clear that privacy is valued as an issue of prime importance by most Americans.
- There is increasing pressure on private and public institutions to operate in a "fish-bowl" atmosphere. In the public sector, the influence of the Freedom of Information Act is perhaps just starting to be felt.
- One of the most important problems to be addressed is the dilemma of access to information vs. privacy of information. There is virtually no verifiable data on the relationships among individual access, data bases,

and privacy. In fact, even generally acceptable definitions of the terms themselves do not exist.

- The focus should be on information access rather than computer access. In many instances, we must deal with strongly interlocking "bundles of rights" (e.g., doctor-patient-hospital).
- The host of myths about computers, data bases, and access include the following.
  - No differentiation is usually made between individual and corporate rights.
  - The validity of attitudinal data bases is accepted even where data are weak and conflicting.
  - Natural monopoly is assumed as given when, in fact, it is government-granted or government-acquiesced (cost vs. output curves are U-shaped rather than monotonically decreasing).
  - Cross-subsidization is accepted as an equitable strategem even though it is, in effect, a rationalization dictated by ease of price setting.

E. PANEL REPORTS

Four panels were organized to address specific sets of subissues related to computer and information access. The focus of each panel was directed at one of the following substantive aspects of access: societal, technological and economic, political, and legal/judicial. In the summaries that follow, the comments of the panelists are interspersed with observations made by other workshop participants.

Societal Focus (Ithiel de Sola Pool, Frederick B. Thompson, and Joseph Weizenbaum)

- An urgent need was registered for a precise definition, and possibly a taxonomy, of *access*. A matrix of "sectors of society" vs. "immediacy of contact with an information or computer system" was proposed. It was also noted that access may be viewed in its simplest terms as the ability or capability (varied as it may be) to use an information system.
- Two distinct points of leverage can be used to promote widespread access to computer systems:

  - the education of children to make them feel at home with computers at an early age; and
  - a pricing policy that does not act as a deterrent (the communication system, rather than the computer, is key here) to contact with information systems.

- Unless we examine the options carefully we may inadvertently lock ourselves into particular information-system designs without appreciating the full implications of the choices being made, much as we have locked ourselves into the present automobile transport system.
- Access to information systems encloses subjects in an envelope of perceptions and an environment that may not be worth the price. It is important to understand how, for example, MIS or CAI users differ from nonusers in terms of how they frame questions, make needs known, organize themselves, and generally function in society. In other words, we should take a hard look at whether, and how, computer systems are helping to socialize the individual. The panelists felt that present computer applications generally increase the gap between social groups with respect to their ability to compete economically and with respect to the validity of their perceptions about computers. Such a gap seems to be a byproduct of using sophisticated techniques that require complex intellectual skills.
- Note was also made of the role that access to computer systems can play in putting man more in a "supervisory" position (or position of control) in some areas. Both his self-image and opportunities for diversity of experience can be enhanced. This is particularly true in the manufacture of products by computer-managed parts programming or by the operation of computer-managed job shops--both resulting in the availability of a wide variety of product characteristics.
- The panelists voiced several concerns about increased product diversity.
  - Most highly advertised product differences are trivial and operate to restrict rather than expand individual choice.
  - Since product diversity entails social and economic costs of some kind, some reasonable bounds on product choices should be set at the outset.

  - Most people are incapable of dealing with product diversity, even at fairly low levels of choice. Often there is little good information available on which to base a meaningful decision.

- The social effects of computers are potentially large, uncertain, and irreversible. The extent to which their effects can be assessed in an anticipatory fashion (i.e., technology assessment) is very much an open question.
- The central concern may, in effect, be with the democratic uses of technology; and perhaps some good examples already exist in which a powerful technology (i.e., nuclear energy) did not become the exclusive province of a particular segment of society. More democratic use of computer technology, however, does not necessarily imply more computer access as much as it does imply more information sharing about computer systems and uses.

Technological and Economic Focus (Robert Kling, Daniel D. McCracken, and Lee L. Selwyn)

- We already have, or are about to have, the computer hardware and software that could provide a variety of socially related services (e.g., health, education, legal aid, and jobs) at a reasonable cost to those large segments of society that are in need of such services. Actually, the best computer-based services are available to the wealthy in urban areas. Neither technology nor economics is the principle barrier to wider distribution of computer-based services.
- Access to a range of socially related services for disadvantaged groups can indeed result in some redistribution of power. However, it is naive to believe that the application of computer technology per se will operate to redress social inequities. A host of political and economic realities has to be addressed before any real changes or shifts in exercise of power take place.
- Information systems have the ability to enhance the power of sophisticated users. To the extent that computer-based aids are most available to those who already have substantial power, the current power differences are enhanced. This observation applies to power balances between

government bureaus, organizational departments, and other groups, not simply between individuals and bureaucracies.

- In a sense, we have a solution (computer technology) in search of a problem. Although some examples do exist of pervasive technologies having created power redistributions (e.g., automobiles and libraries), the role of computer technology in this respect may have to be aided by the creation of appropriate social intermediaries to function between computer systems and the social groups that are to be affected.
- We should be careful not to think strictly in terms of hardware when we consider computer access. Many socially related data-collection efforts involving computer processing do not contribute to the welfare of disadvantaged groups or geographical sectors (e.g., Watts). Although it may not be very meaningful to use the term *computer power*, increasing attention is likely to be directed to the ways in which computer applications affect social policy.
- A particularly attractive area for increasing computer services is the collection, organization, and dissemination of employment- or job-related information.

Political Focus (Michael A. Baker, Thomas B. Sheridan, and Marshall H. Whithed)

- Access to computers may be limited, even for social elites, by language or linguistic problems.
- It is very unclear at this time whether computerization contributes to conformity or diversity in social affairs.
- Citizens' access to computers can contribute to: (1) the balancing of power where anonymity may be preserved; (2) the muting of social alienation; and (3) the increase of citizen efficacy. There is some evidence that simulation/gaming can enhance political efficacy of citizens. Several efforts are now underway (although not yet implemented) to provide citizen access to computer-simulation and planning systems (e.g., San Diego, Toronto, and Nottingham).
- The awe of the computer may indeed have acted in both political and military arenas to perpetuate elites who have technically sophisticated staffs or consultants. A closer study of the ways in which control of

information and power may be correlated in public life would need to include an examination of whether particular political candidates have allocated substantial financial resources for surveys on opinions of constituencies.

- General research on public attitudes toward computers and how computers are used in decision making will probably not be very productive. Instead, progress will be made primarily by collecting data on how people behave under specific legislation on privacy and confidentiality and how decisions are made under such circumstances.
- The computer is unlikely to resolve the most important questions on the wielding of political power, citizen participation, and the like. What the computer may do is eliminate excuses for not redistributing or sharing political power at a number of levels. At the same time, care must be exercised that the computer and the software systems are not used as an excuse for depriving some social groups of their rightful share of political power.

Legal/Judicial Focus (Robert P. Bigelow, Michael A. Duggan, Hope Eastman, and David B. H. Martin)

- The panelists proposed a taxonomy for computer access in which the extensiveness of access (e.g., intrasystem, network, or internetwork) is played against the accessing entity (e.g., individual, institution, or government).
- Skepticism among panelists about citizen participation included: (1) doubts that citizens really desire to participate; (2) the danger of "instant referenda"; and (3) the degree of participation that is desirable in a democracy. Perhaps citizen participation is best for promoting dialogue, not referenda.
- Inequities in the administration of justice can easily result whenever the individual is pitted against the government in public-interest legislation. (The IBM/CDC controversy and the destruction of document indices are cases in point.)
- There are no data on the inhibitory influence of undifferentiated data. Some initial efforts are now getting underway to do research in this area.

- The government is not necessarily operating increasingly in a "fish-bowl" environment. (One example cited was the recent attempt to define *information theft* as *property theft*, although federal law does not so define it.)
- Two contrasting sets of observations can be made regarding privacy.
    - On the one hand, it is contended that the increasing use of the Social Security number, the lack of consumer resistance in eliciting credit-card data, and increasing evidence that most people are almost eager to provide personal data can lead to the conclusion that privacy is not highly valued by most citizens.
    - On the other hand, it is contended that the apparent indifference to the privacy issue exists only because most people do not realize that increasing amounts of personal data are being exchanged by institutions or that the Bank Secrecy Act now introduces a third party (i.e., government) between the individual and the bank. In fact, "privacy-impact" statements should perhaps become a standard element before approval is given to proceed with the implementation of large information systems.
- Privacy and secrecy are different, but they can perhaps be viewed as opposite sides of the same coin. Thus, most of us find that we are for privacy but against secrecy. The rhetoric of protection of client/citizen privacy may be used increasingly to mask power fights over control of information.
- Some panel members felt that research on access must be tied to specific case studies that focus on what is being done on access, privacy, and confidentiality, and with what impact and consequences. We need a clearer understanding of the extent to which accessibility to more information makes individuals better consumers or citizens. Others felt that data are needed on computer perceptions, including: (1) unrealistic attributions that people make to computers; (2) how these feelings are generated; and (3) the policy decisions that result because of these perceptions. For example, many people ascribe to computers the ability to think, to make judgmental decisions, to do language translation, to make value judgments, to be reliable, and so forth.

F. GUIDELINE QUESTIONS FOR THE WORKSHOP

How does increasing access to computers by individuals and institutions influence the rules by which we live and by which society functions? What requirements for additional data are suggested, what monitoring should be initiated, and what research should be done in order to develop improved understanding of the major issues raised by increasing access and/or differential accessibility by various social groups? What requirements, in turn, are created for equipment and software design and development, education and training, standards and regulatory measures, institutional innovation, and the like?

Societal Questions

1. How does increasing access to computers operate to encourage more or less conformity (or more or less diversity) in society?
2. What impact will increasing access to computers have on man's self-image, and will this have a large impact on society?
3. To what extent, and how, does access to computers operate to increase or decrease the gaps between economic, political, or social "haves" and "have nots"?

Technological and Economic Questions

1. What is the state of the art of computer technology now, and what is it likely to be in the next ten years, insofar as the application of such technology may permit increasing computer access by various social groups?
2. How are the costs of access to computing systems likely to create dissymmetries in, and barriers to, access to vital information among various social groups?
3. What new institutional forms (e.g., community information centers) may emerge as a result of technological and economic developments related to computer access?
4. Should the forces of the existing marketplace be allowed to shape new institutional forms (e.g., the way TV developed), or should there be government developmental subsidies to shape these forms in a more socially desirable way?

Political Questions

1. How are the control of information and power correlated in public and private affairs? What role may computer access play here?
2. How can increasing computer access be used to enhance citizen participation in democratic processes? Is this desirable?
3. To what extent, and how, does access to computers serve to create conditions that perpetuate the tenure of individuals and institutions holding positions of political or economic power?

Legal/Judicial Questions

1. How might differential access to data bases result in inequities in the administration of justice?
2. What inhibitory influences on individual behavior may result from the knowledge that others have access to personal information?
3. How may the increasingly "fish-bowl" nature of government and business affect the structure of each?

APPENDIX A
FRAMEWORK FOR ASSESSING SOCIAL IMPACT

Social impact can be an elusive, although intuitively appealing, notion. Yet it is crucial to sharpen the definition of the concept, because the evaluation of each candidate program area depends directly on the ability to make judgments about the likely contribution of each area to an understanding of the social impact of computers. For the purposes of this evaluation, the impacting process is viewed within a framework of three interacting elements. Each element provides a check list or relevance tree of useful indices associated with the information system, the societal system, or the value system.

Within an information system, computer impact may be sensed by changes in key physical parameters. The introduction of computer technology into any real-world situation--if it is significant--may create changes in how data is collected, generated, analyzed, processed, stored, and disseminated. If this were not so, then its impact would be either negligible or very difficult to trace. The ability to discern and measure changes in basic cybernetic variables--data rates, data paths, and memory sizes--thus can provide the starting point for any assessment of social impact. This is not to say that changes in such physical operating characteristics provide definitive answers on the magnitude and nature of such impact. Rather, they provide rough screening clues for directing attention to other elements.

Within the social system with which an information system interacts, the relevant indices deal more directly with societal impact, although still in somewhat aggregated form. Judgment and intuition necessarily play a greater role in assessments here. A number of measures may be used, including changes or transfers in knowledge, power, wealth, income, structure (e.g., industrial structure), and goods and services (e.g., modes of production or delivery). Again, such changes or transfers can provide clues on the magnitude or nature of social impact attributable to the computer.

Finally, within the value system, impact may be measured in terms of those quality-of-life indicators that are the most disaggregated, personal, and value-laden. Among the indicators are privacy, equality of opportunity, choice, diversity, openness, participation, human control, customization, gainful employment, and many others. Ultimately, the assessment of social impact requires judgments about the relationship of choices involving computer uses to the likely impact which such choices will have on these indices of personal well-being.

APPENDIX B
BIOGRAPHIES OF WORKSHOP PARTICIPANTS*

AMARA, ROY (1, 2, 3, 4, 5)

President, Institute for the Future, 1970-present; Stanford Research Institute, in a variety of positions including Vice President, Institute Programs, and Executive Director, Systems Sciences Division, 1952-69. Primary areas of activity (and publications) are control systems; network design; computer applications in banking, airline, defense, and satellite systems; technology forecasting and assessment. Education--B.S., Massachusetts Institute of Technology; M.A., Harvard University; Ph.D., Stanford University.

ANDERSON, RONALD E. (3)

Assistant Professor, Department of Sociology, and Director, Social Science Research Facilities Center, University of Minnesota, 1968-present; Instructor, Stanford University, 1967-68; Instructor, San Francisco State College, 1966-67. Publications--"Wrapping the Package: Critical Comments on Social Data Analysis Packages", in *Computers and the Humanities* (November 1972); "Sociological Analysis of Public Attitudes Toward Computers and Information Files", in *Proceedings of the Joint Computer Conference* (Spring 1972); "Sociology, Computers, and Undergraduate Mass Education", in *Proceedings of a Conference on Computers in the Undergraduate Curricula* (University of Iowa, 1970). Education--B.A., La Sierra College; M.A., Ph.D., Stanford University.

---

*The number(s) following each participant's name indicates the workshop(s) in which he was involved. (1 = Workshop on Computer Modeling and Simulation as an Aid to Decision Making; 2 = Workshop on Computers and Financial Processes; 3 = Workshop on Computer Perceptions, Attitudes, and Literacy; 4 = Workshop on Computers and Individual Access; 5 = Integration Workshop)

ASHENHURST, ROBERT L. (3)

Professor, University of Chicago, 1965-present; editor, various journals, Harvard University, 1950-57. Publications--"Number Representation and Significance Monitoring", in J. Rice, ed., *Mathematical Software* (1971); *Balance in Computer Science Education 1970* (1970); "Computation", in *International Encyclopedia of the Social Sciences* (1968). Education--B.A., M.S., Ph.D., Harvard University.

BAKER, MICHAEL A. (4, 5)

Instructor, Department of Sociology, Brooklyn College, City University of New York; Assistant Director, National Academy of Science's Project on Computer Databanks, 1970-72. Publications--coauthor, *Databanks in a Free Society* (1972); "Record Privacy as a Marginal Problem: The Limits of Consciousness and Concern", in *Columbia Human Rights Law Review* (Winter 1972). Education--B.A., Union College; Ph.D. candidate, Columbia University.

BARNES, DONALD G. (2)

Assistant Director, Division of Federal Reserve Bank Operations, Board of Governors of the Federal Reserve System, 1970-present; previously a member of the technical staff, Booz Allen Applied Research, Inc. Education--B.S., Kansas State College; University of Missouri.

BIGELOW, ROBERT P. (4)

Practicing attorney and member of the American Bar Association's Standing Committee on Law and Technology. Publications--editor, *Computers and the Law* (1966, 1969); editor, *The Law Office Economics and Management Manual* (1970); editor, *Computer Law Service* (1972).

BOULDEN, JAMES B. (1)

Chairman of the Board, On-Line Decisions, 1968-present; Associate Professor, School of Business Administration, University of Santa Clara, 1963-69; consultant, 1966-68; Assistant Professor, School of Business Administration, University of California at Los Angeles, 1958-61. Publications--"Multi-dimensional Planning Systems", in *Journal of Long-Range Planning* (September-October 1972); coauthor, "Computerized Corporate Planning", in

Journal of Long-Range Planning (June 1971); "Merger Negotiations: A Decision Model", in *Business Horizons* (1970). Education--B.S., University of Illinois; B.B.A., M.S., Baylor University; D.B.A., Indiana University.

BREWER, GARRY D. (1)

Senior Staff, Social Science Department, The Rand Corporation; Lecturer, School of Public Administration, University of Southern California, 1971-present; consultant, 1969-present; Assistant Professor, Department of Political Science, University of California at Berkeley, 1970-71; member of editorial boards of the journals, *Simulation and Games* and *Public Policy*. Publications--coauthor, *Politicians, Bureaucrats and the Consultant: A Critique of Urban Problem Solving* (1973); coauthor, "Methodological Advances in Political Gaming", in *Simulation and Games* (1972); "Policy Analysis by Computer Simulation: The Need for Appraisal", in *Public Policy* (Summer 1973); *Models, Simulations, and Games--A Survey* (1972). Education--B.A., University of California at Berkeley; M.S., California State University at San Diego; M. Phil., Ph.D., Yale University.

BURGESS, PHILIP M. (3)

Professor, Department of Political Science, Ohio State University. Publications--coauthor, *Theory, Data, and Analysis: An Introduction to Quantitative International Politics* (1972); coauthor, *Indicators of International Behavior: An Assessment of Events Data Research* (1972). Education--B.A., Knox College; Ph.D., American University.

CARLSON, WALTER M. (3, 5)

IBM Corporation, 1967-present; Department of Defense, 1963-67; Du Pont Company, 1939-62. Education--B.S., M.S., University of Colorado.

DENTZER, WILLIAM T., JR. (2)

Chairman of the Board and Chief Executive Officer, Depository Trust Company, 1972-present; New York State Superintendent of Banks, 1970-72; Executive Director, State Council of Economic Advisors, State of New York, 1969-70. He has also held various senior U.S. government positions concerned with international economic development. Education--B.A., Muskingum College; attended law school at Yale University and University of Pennsylvania.

de SOLA POOL, ITHIEL (4)

Professor (1953-present) and Chairman (1959-61 and 1965-69), Department of Political Science, Massachusetts Institute of Technology, 1953-present; Associate Director, RADIR Project, Hoover Institution, Stanford University, 1949-53; taught at Hobart University, 1942-49. Publications--*Candidates, Issues and Strategies* (1964); *The People Look at Educational Television* (1963); *American Business and Public Policy* (1963); *Satellite Generals* (1955); *Symbols of Democracy* (1952). Education--B.A., M.A., Ph.D., University of Chicago.

DUGGAN, MICHAEL A. (4)

Professor, Business Law and Computer Sciences, University of Texas; Visiting Assistant Professor, Economics and Industrial Organization, University of New Hampshire, 1967-69; Trial Attorney, Antitrust Division, U.S. Department of Justice, 1961-67. Fields of present interest include societal, legal, and economic problems of cybernetics, communications, atomic energy, regulation, and competition. Education--B.S., College of the Holy Cross; J.D., Boston College Law School; M.P.L., Georgetown University Graduate Law School.

EASTMAN, HOPE (4)

Associate Director, Washington National Office, American Civil Liberties Union; formerly Attorney-Advisor, Office of Legal Advisor, U.S. Department of State. Education--B.A., University of California at Los Angeles; L.L.B., Harvard University Law School.

EDELHERTZ, HERBERT (2)

Research Scientist (1972) and Director (1971-73), Law and Justice Study Center, Battelle Human Affairs Research Centers, 1971-73; Acting Chief, Center for Law and Justice, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, 1969-71; Chief (1966-69) and Deputy Chief (1963-66), Fraud Section, Criminal Division, U.S. Department of Justice, 1962-69; private practice of law in New York City, 1949-62; partner, Tompkins, Lauren and Edelhertz, 1958-62; special counsel to New York Joint Legislative Committee on Charitable and Philanthropic Agencies and Organizations, 1954-55. Publications--*Compensating Crime Victims* (forthcoming); "The Research Process as a Factor in Implementation of Design for Criminal Justice Change", in *Proceedings of the Fourth National Symposium on Law Enforcement Science and Technology* (forthcoming); *The Nature, Impact and Prosecution of White Collar Crime* (1970). Education--B.A., University of Michigan; LL.B., Harvard University Law School.

FARRAR, DONALD E. (2, 5)

Senior Research Associate and Assistant to the President, National Bureau of Economic Research. He has taught at the University of Wisconsin, Massachusetts Institute of Technology, and Columbia University, and was a Senior Fellow, Center for Study of Financial Institutions, University of Pennsylvania Law School. Publications--*Institutional Investor Study Report* (1971); coauthor, *Managerial Economics* (forthcoming); *Investment Decision Under Uncertainty* (1967). Education--B.A., M.A., Ph.D., Harvard University.

FROMM, GARY (1)

Professor, Department of Economics, American University; Senior Fellow Consultant, Brookings Institution; Senior Research Associate, National Bureau of Economic Research. Publications--coauthor, "A Comparison of Eleven Econometric Models of the United States", in *American Economic Review* (May 1973); "Implications To and From Economic Theory in Models of Complex Systems", in *American Journal of Agricultural Economics* (March 1973); "Econometric Models in Economic Planning Control Mechanisms", in *IFAC Proceedings* (September 1971); and six books on economic modeling, analysis, and simulation. Education--B.M.E., Cornell University; M.S., Massachusetts Institute of Technology; M.A., Ph.D., Harvard University.

GIESE, PAUL E. (2)

Senior Member, Financial Industries Section, Arthur D. Little, Inc.; Boeing Company. Publications--"Automation in the Age of the User", in *The*

Challenge of Change in Banking (1972); coauthor, "Now Its the Less-Check Society", in *Harvard Business Review* (November/December 1972). Education--B.S., M.B.A., University of Washington.

GOLDSTEIN, JOEL W. (3, 5)

Assistant Professor, Psychology and Industrial Administration, Carnegie-Mellon University, 1966-present; University of Kansas, 1961-66. Publications are in drug usage and education, interpersonal relations, and social motivation, including "On the Significance of Increasing Student Marijuana Use for Intended Use of Other Drugs", in *Proceedings, 81st Annual Convention, American Psychological Association* (1973); "Motivations for Psychoactive Drug Use Among Students", in *Readings in Essentials of Abnormal Psychology*. Education--B.A., Grinnell College; M.A., Ph.D., University of Kansas.

GREENBERGER, MARTIN (1)

Professor, Mathematical Science (1972-present), Professor and Chairman, Department of Computer Science, and Director, Information Processing (1967-72), Johns Hopkins University, 1967-present; Assistant Professor and Associate Professor, Massachusetts Institute of Technology, 1958-67; Teaching Fellow, Harvard University, 1954-58. Publications--editor, *Computers, Communications, and the Public Interest* (1971); coauthor, *On-Line Computation and Simulation: The OPS-3 System* (1965); coeditor, *Management and the Computer of the Future* (1962); *Microanalysis of Socioeconomic Systems: A Simulation Study* (1961). Education--B.A., M.A., Ph.D., Harvard University.

HALL, ROBERT C. (2)

President and Chairman of the Board, Securities Industry Automation Corporation, 1972-present; Vice President and Group Executive, Customer Systems, Control Data Corporation; President, Holley Computer Products; Sundstrand Corporation; Stewart-Warner Corporation. Education--B.S., Iowa State University.

HUNT, EARL B. (1)

Professor, Psychology and Computer Science, and Chairman, Department of Psychology, University of Washington, 1966-present; Associate Professor, Business Administration and Psychology, University of California at Los Angeles 1965-66; Senior Lecturer, Physics (Electronic Computing), University of Sydney, 1963-65; Western Management Science Institute, University of California at Los Angeles, 1961-62; Assistant Professor, Yale University, 1960-61; Psychological Research Associates, 1959. Publications--*Experiments in Induction* (1966); *Concept Learning: An Information Processing Problem* (1962). Education--B.A., Stanford University; Ph.D., Yale University.

JACOBS, DONALD P. (2)

Chairman (1969-present), Department of Finance, Graduate School of Management, Northwestern University, 1957-present; Research Associate, National Bureau of Economic Research, 1966-70; Instructor, City College of New York, 1955-57; Research Staff, National Bureau of Economic Research, 1952-57. Publications--coauthor, *The Impact of Electronic Money Transfers on the Savings and Loan Business* (1972), coauthor, *Financial Institutions* (1972); coauthor, "Problems in Developing a Bank Information System", in *Proceedings of Information Systems Symposium* (August 1967). Education--B.A., Roosevelt College; M.A., Ph.D., Columbia University.

JUSTICE, C. RICHARD (2)

Senior Vice President, National Association of Securities Dealers, 1972-present, and Executive Vice President, National Clearing Corporation, 1970-present, the Mitre Corporation, 1962-68; System Development Corporation, 1955-62. Education--B.A., Washington and Jefferson College; University of Chicago.

KAY, ALAN F. (2)

President, AutEx, Inc., 1966-present; Vice President and Member of the Board of Directors, TRG, Inc., 1954-66. Education--B.S., Massachusetts Institute of Technology; Ph.D., Harvard University.

KIVIAT, PHILIP J. (1, 5)

Technical Director, Federal Computer Performance Evaluation and Simulation Center (1972-present); Systems Control, Inc., 1971-72; President, Simulation Associates, 1969-71; Rand Corporation, 1963-69; U.S. Steel Corporation, 1961-63. Associate Editor of the journal, *Simulation;* Chairman, College of Simulation and Gaming, The Institute of Management Sciences. Publications--*The SIMSCRIPT II Programming Language* (1969); coauthor, *Simulation with GASP II* (1969). Education--B.S.M.E., M.I.E., Cornell University.

KLING, ROBERT (4)

Assistant Professor, Department of Information Sciences, and Research Associate, Public Policy Research Organization, University of California at Irvine; Assistant Professor, Department of Computer Sciences, University of Wisconsin, 1971-73; Stanford Research Institute, 1966-71. His research is in the areas of complex information-processing systems, heuristic problem solving, robots, and educational consulting. Publications--"Towards a Person-Centered Computer Technology", in *Proceedings, 1973 ACM National Conference,* and technical contributions to the literature of reasoning by analogy as an aid to automatic problem solving. Education--B.A., Columbia University; M.S., Ph.D., Stanford University.

LARSON, HARRY T. (3)

Director of Operations Planning, California Computer Products. He has also worked for the National Bureau of Standards, Hughes Aircraft, TRW, Aeronutronic Division of Philco/Ford. Education--B.S., University of California at Berkeley; M.S., University of California at Los Angeles.

LYKOS, PETER (5)

Professor (1964-present), Illinois Institute of Technology, 1955-present; recently completed two years of work with the Division of Computer Research, National Science Foundation, where he created a new program entitled Computer Impact on Society. He is a National Lecturer for the Association for Computing Machinery (ACM) and is chairman of ACM's Special Interest Group on Computers and Society. Education--B.S., Northwestern University; Ph.D., Carnegie-Mellon University.

MARTIN, DAVID B. H. (4)

Special Assistant to the Secretary of Health, Education and Welfare, 1970-present, and Executive Director of the Secretary's Advisory Committee on Automated Personal Data Systems, 1972-present; Senior Consultant and Acting Deputy Director, Urban Law Institute, The National Law Center, The George Washington University, 1970. Education--B.A., Yale University; L.L.B., Harvard University.

MARVICK, DWAINE (3)

Professor (1957-present), Department of Political Science, University of California at Los Angeles, 1954-present; University of Michigan, 1953-54. Publications--*Career Perspectives in a Bureaucratic Setting; Political Decision Makers;* coauthor, *Campaign Pressures and Democratic Consent.* Education--Ph.D., Columbia University.

McCRACKEN, DANIEL D. (4)

Author of a number of textbooks on computer programming and chairman of the Association for Computing Machinery's Committee on Computers and Public Policy. Publications--*Public Policy and The Expert* (1971); coeditor, *To Love or To Perish: The Technological Crisis and The Churches* (1972). Education--B.A., Central Washington State College.

McKAY, NEIL (2)

Executive Vice President and Cashier, The First National Bank of Chicago, and Executive Vice President and Secretary, First Chicago Corporation, 1963-present; member/partner of the Chicago law firm of Winston, Strawn, Smith, & Patterson, 1946-63. Education--B.A., University of Michigan; J.D., University of Michigan Law School.

McQUOWN, J. A. (2, 5)

Vice President, Management Sciences Department (1968-present), Wells Fargo Bank, 1964-present. Education--B.S., Northwestern University; M.B.A., Harvard University; New York University.

MEADOWS, DENNIS L. (1)

Professor, Dartmouth College, 1972-present; Assistant Professor, A. P. Sloan School of Management, Massachusetts Institute of Technology, 1969-72; Director, Project on the Predicament of Mankind, 1970-72. Publications--coauthor, *The Limits to Growth* (1972); coauthor, *Town and Global Equilibrium* (1972); *Dynamics of Commodity Production Cycles* (1970). Education--B.A., Carleton College, Ph.D., Massachusetts Institute of Technology.

MEIER, RICHARD L. (1)

Professor, Environmental Design, University of California at Berkeley, 1967-present; Research Chemist, Standard Oil of California; Executive Secretary, Federation of American Scientists; Assistant Professor, University of Chicago; Associate Professor, University of Michigan. Publications--*Communications Stress* (1972); *Resource-Conserving Urbanism: Progress and Potentials* (1971); *Science and Economic Development* (1966); *A Communications Theory of Urban Growth* (1962). Education--B.S., University of Illinois; Ph.D., University of California at Los Angeles.

MELNIKOFF, MEYER (2)

Senior Vice President (1966-present) and Actuary, Prudential Insurance Company of America, 1939-present. Education--B.A., M.A., Montclair State College.

MEYER, JOHN R. (2)

Professor, Yale University, and President, National Bureau of Economic Research. Publications--coauthor, *The Role of Transportation in Regional Economic Development* (1971); coauthor, *Managerial Economics* (1970); coauthor, *Techniques of Transport Planning* (1970); coauthor, *Investment Decisions, Economic Forecasting & Public Policy* (1964). Education--B.A., University of Washington; Ph.D., Harvard University.

MORGAN, DAVID H. (2)

President, National Clearing Corporation; Director, National Clearing Corporation; Director, Depository Trust Company; President, Pacific Coast

Stock Exchange Clearing Corporation; Peat, Marwick, Mitchell & Co.; U.S. Steel Corporation. Education--B.S., Northwestern University.

MORGAN, M. GRANGER (1, 2, 3, 4, 5)

Program Director, Computer Impact on the Individual Program, Division of Computer Research, National Science Foundation; Director, Computer Jobs Through Training, and Lecturer (1970-71) and Acting Assistant Professor (1971-72), Department of Applied Physics and Information Science, University of California at San Diego, 1969-72. Education--B.A., Harvard University; M.S. Cornell University; Ph.D., University of California at San Diego.

NATHANS, ROBERT (3)

Professor, Physics and Engineering, and Chairman, Department of Urban Science and Engineering, State University of New York at Stony Brook, 1968-present; Senior Physicist, BNL, 1960-68; Physicist, Massachusetts Institute of Technology, 1956-60; Professor, University of Osaka, Japan, 1958-59; Associate Professor, Physics, Pennsylvania State University, 1954. Education--B.S., University of Delaware; M.S., University of Minnesota; Ph.D., University of Pennsylvania.

NOVICK, DAVID (2)

Head, David Novick Associates; Rand Corporation, where he continues as a consultant, 1949-71. He has also held a wide range of positions in universities, government, and business. Publications--*Current Practice in Program Budgeting (PPBS)* (1973); *Program Budgeting* (1967).

PHILLIPS, ALMARIN (2)

Chairman, Department of Economics, University of Pennsylvania. He has also taught at Ohio State University, London Graduate School of Business Studies, University of Warwick, University of Hawaii, University of Pennsylvania, University of Virginia, and Harvard University. Publications--*Technology and Market Structure: A Study of the Aircraft Industry* (1971); coeditor, *Prices: Issues in Theory, Practice and Policy* (1968); editor, *Perspectives and Anti-trust Policy* (1965). Education--B.S., M.A. University of Pennsylvania; Ph.D., Harvard University.

SEDELOW, SALLY YEATES (3)

Professor, Computer Science and Linguistics, University of Kansas, 1970-present; Associate Professor, English and Computer & Information Science, University of North Carolina, Chapel Hill, 1966-70; consultant, System Development Corporation, 1964-67; Assistant Professor, English, St. Louis University, 1964-66; Human Factors Scientist, System Development Corporation, 1962-64. Publications--coauthor, *The Computer and Language Research: A Study of the Concept of a National Center/Network for Computational Research on Language;* coauthor, "Models, Computing, and Stylistics", in *Current Trends in Stylistics* (1972); "The Computer in the Humanities and Fine Arts", in *Computing Surveys* (June 1970). Education--B.A., University of Iowa; M.A., Mount Holyoke College; Ph.D., Bryn Mawr College.

SELWYN, LEE L. (4)

President, Economics and Technology, Inc., and member of the faculty, College of Business Administration, Boston University. His publications include a wide variety of papers and articles on the economics of computer and telecommunications, public policy, financial management, and the merging of computer and telecommunications technology. Education--B.A., Queens College; Ph.D., Massachusetts Institute of Technology.

SHERIDAN, THOMAS B. (4, 5)

Professor, Department of Mechanical Engineering (1970-present), Massachusetts Institute of Technology, 1956-present; consultant to General Electric, General Motors, Biodynamics, and Westinghouse. Professional interests include mathematical models of human operator in control systems, remote manipulation, and man/computer interactions. Education--B.S., Purdue University; M.S., University of California at Los Angeles; Sc.D., Massachusetts Institute of Technology.

SMITH, WILLIAM D. (3)

New York Times, 1959-present. Publications--*Northwest Passage: The Voyage of the S.S. Manhattan.* Education--B.A., Columbia College.

SPOFFORD, WALTER O., JR. (1)

Research Associate, Resources for the Future, 1968-present; Captain, U.S. Army, 1966-68; Research Fellow, Center for Population Studies, Harvard University, and Ford Foundation Consultant in Egypt, 1965-66; Research Assistant, Harvard University, 1961-65. Publications--coauthor, "A Quantitative Framework for Residuals Management Decisions", in *Environmental Quality Analysis: Theory and Method in the Social Sciences* (1972); "Residuals Management: An Overview of the Global Problems", in *Man's Impact on Terrestrial and Oceanic Ecosystems* (1971). Education--B.S., Northwestern University; M.S., Ph.D., Harvard University.

TANNENBAUM, PERCY H. (3)

Professor, Graduate School of Public Policy, University of California at Berkeley, 1970-present; Professor, Communication and Psychology, University of Pennsylvania, 1967-70; University of Wisconsin, 1959-67; University of Illinois, 1954-58; Michigan State University, 1953-54; University of Illinois, 1950-53. Publications--"Replacement of Words in Hesitation Environments", in *The Psychosociology of Language* (1972); "The Individual as a Receiver System", in *Communication and Development;* coeditor/coauthor, *Theories of Cognitive Consistency* (1968). Education--B.S., McGill University; M.S., Ph.D., University of Illinois.

TAVISS, IRENE (3)

Harvard University, 1966-present; has also taught at Brooklyn College. Publications--*Our Tool-Making Society* (1972); coeditor, *Human Aspects of Biomedical Innovation* (1971); editor, *The Computer Impact* (1970). Education--B.A., Brooklyn College; Ph.D., Harvard University.

THOMPSON, FREDERICK B. (4)

Professor, Applied Science and Philosophy, California Institute of Technology, 1965-present; Project Engineer, Information Systems Theory Project, General Electric Company, 1959-65. Publications--"The Nature and Role of Data in Command and Control", in *Proceedings of the National Meeting of the American Psychological Association* (1964); "Man-Machine Communications", in *Proceedings of Seminar on Computational Linguistics* (1966); "How Features

Resolve Syntatic Ambiguity", in *Proceedings of National Symposium on Information Storage and Retrieval* (1971); "The Future of Specialized Languages", in *Proceedings of SJCC* (1972); "The REL System", in *Proceedings of Symposium on Computer and Information Science* (1972). Education--B.A., M.A., University of California at Los Angeles, Ph.D., University of California at Berkeley.

VEROUGSTRAETE, JAMES R. (1)

Associate Director for Regional Analysis, San Diego Regional Council of Governments, 1970-present; Associate Professor and Project Director, University of Tennessee, 1968-70; Tri-County Regional Planning Commission, Michigan, 1964-68. Publications--coauthor, *CPO Regional Model System: A Non-Technical Description* (1972); *Population and Housing Estimating Systems* (1971); coauthor, *Urban Development Models and the Regional Planning Process*. Education--B.S., M.S., Michigan State University.

WARE, WILLIS H. (1, 5)

Senior Computer Scientist, Rand Corporation. Publications--*The Ultimate Computer* (1972); *Computers in Society's Future* (1971); *Limits of Computing Power* (1971); *Computer Data Banks and Security Controls* (1970). Education--B.S., University of Pennsylvania; M.S., Massachusetts Institute of Technology; Ph.D., Princeton University.

WEATHERSBY, GEORGE B. (1)

Associate Director, National Commission on the Financing of Postsecondary Education and White House Fellow, 1973; Special Assistant to the Secretary of State and White House Fellow, 1972; Associate Director, Analytical Studies, Office of the President, University of California, 1969-72. Publications--"Educated Manpower and National Goals", in *Manpower* (1972); coauthor, *Statewide Planning for Postsecondary Education: Issues and Design* (1971); coauthor, *Outputs of Higher Education: Their Identification, Measurement, and Evaluation* (1970). Education--B.S., M.S., M.B.A., University of California at Berkeley; M.S., Ph.D., Harvard University.

WEINGARTEN, FRED W. (*)

Program Director, Special Projects, Division of Computer Research, National Science Foundation, 1972-present; Director, Institute for Educational Computing, The Claremont Colleges, Assistant Professor, Department of Computer Science, Harvey Mudd College, and Member, Faculty in Mathematics, Claremont Graduate School, 1969-72. Publications--"An Educational Computing Network", in *Proceedings of ON-LINE 72 Conference, Brunel University, Uxbridge, England* (1972); "An Analysis of Regional Computing", in *Proceedings of First Symposium of the Pacific Northwest Cooperative Computing Center* (1972); *An Introduction to the Educational Use of the Computer* (1972). Education--B.S., California Institute of Technology; M.S., Ph.D., Oregon State University.

WEIZENBAUM, JOSEPH (4)

Fellow, Center for Advanced Study in the Behavioral Sciences, Stanford University; on leave from Massachusetts Institute of Technology, where he is a Professor of Computer Science. Professional interests include artificial intelligence, and imminent and actual interplay of computer technology and society.

WHITE, GEORGE C., JR. (2)

Vice President and Operations Planning Executive, The Chase Manhattan Bank, 1972-present; Vice President, Irving Trust Company. He represents Chase Manhattan Bank on the Payment Systems Committee at the New York Clearing House Association and is chairman of the Committee's Future Plans Subcommittee. His publications include a number of speeches and articles on the electronic transfer of funds and securities. Education--B.S., Purdue University; Massachusetts Institute of Technology.

WHITE, THOMAS (3)

Director of Communications, American Federation of Information Processing Societies. He has also worked for Mutch Haberman Joyce (an advertising and public relations firm) and M. W. Kellogg Company Division of Pullman Incorporated.

---

*A National Science Foundation observer for Workshops 1, 2, 3, and 4.

WHITHED, MARSHALL H. (4)

Assistant Professor, Department of Political Science, Temple University. Publications--"Urban Dynamics and Public Policy", in *IEEE Transactions on Systems, Man, and Cybernetics* (1972); editor, *Urban Simulation Handbook* (1972); "Technological Analysis and Democratic Policy-Making", in *SIGCSE Bulletin: A Quarterly Publication of the Special Interest Group on Computer Science Education* (1972); "Computer-Based Urban Planning Systems and the User Interface", in *Proceedings of 7th Annual ACM Urban Symposium, New York* (1972). Education--B.A., M.A., University of Massachusetts; Ph.D., Tufts University.

YAMAMOTO, WILLIAM S. (1)

Chairman and Professor, Department of Clinical Engineering, George Washington University Medical Center, 1971-present; Biomedical Electronic Engineering, University of Pennsylvania, 1968-71; Professor, School of Medicine, University of California at Los Angeles, 1970-71; Professor, School of Medicine, University of Pennsylvania, 1953-71. Publications--"Computers in Physiological Modelling", in *AFIPS Conference Proceedings* (1971); editor, "Symposium on Application of Control Systems Theory to Physiology", in *Federation Proceedings*. Education--B.A., Park College; M.D., University of Pennsylvania Medical School.

REFERENCES

Alker, H. R., Jr., and Bonner, R. D., "Simulating International Conflict", *International Studies Quarterly*, vol. 3 (March 1969).

American Federation of Information Processing Societies, news release on the 1971 Fall Joint Computer Conference, Las Vegas, 16 November 1971.

Anderson, Ronald E., "First Progress Report on an Inventory of Research Measuring Perceptions of Computerization", paper presented to the Workshop on Computer Perceptions, Attitudes, and Literacy, Institute for the Future, Spring 1973.

Anderson, Ronald E., "Inventory of Research Measuring Perceptions", University of Minnesota (n.d.), mimeographed.

Armer, Paul, *The Individual: His Privacy, Self-Image and Obsolescence*, presented to U.S. Congress, House, Committee on Science and Astronautics, Panel on Science and Technology, Eleventh Meeting (January 1970).

Armer, Paul, *Computer Aspects of Technological Change, Automation, and Economic Progress*, Report to the National Commission on Technology, Automation, and Economic Progress (September 1965).

Ashenhurst, R. L., "The Problem of Computer Literacy", paper presented to the Workshop on Computer Perceptions, Attitudes, and Literacy, Institute for the Future, Spring 1973.

Baker, Michael A., "Political Aspects of Access to Computerized Record Systems and Computing Facilities", paper presented to the Workshop on Computers and Individual Access, Institute for the Future, Spring 1973.

Behrens, William, III, and Meadows, Dennis L., *Determinants of Long Term Resource Availability*, Thayer School of Engineering, Dartmouth College (October 1972).

Black, Fischer, "Toward a Fully Automated Stock Exchange", *Financial Analysts Journal* (July/August 1971), pp. 28-35 and 44.

Black, Fischer, "Toward a Fully Automated Stock Exchange", *Financial Analysts Journal* (November/December 1971), pp. 25-28 and 86-87.

Boulden, James B., and Buffa, Edward S., Jr., "Corporate Models: On-Line Real Time Systems", *Harvard Business Review* (July/August 1970).

Brewer, Garry D., and Hall, Owen P., Jr., *Policy Analysis by Computer Simulation: The Need for Appraisal*, P-4893, The Rand Corporation (August 1972).

Burgess, Philip M., and Ballard, Steven C., "Intrusion, Control, and Trust: The Problem of Record Keeping and Privacy in Modern Society", The Ohio State University (n.d.), mimeographed.

"Checkless Society Due for Big Steps", *Computerworld,* vol. 7, no. 15 (1973).

Coates, Vary T., *Technology and Public Policy: The Process of Technology Assessment in the Federal Government*, vols. 1 and 2, Program of Policy Studies in Science and Technology, The George Washington University (July 1972).

Cousins, Norman, "Humans versus the Computer", *World* (13 February 1973), pp. 18-19.

Cox, Edwin, and Giese, Paul, "Now It's the 'Less-Check' Society", *Harvard Business Review* (November/December 1972).

"Cutting the Big Board Down to Size", *Datamation* (April 1973), pp. 108-109.

Dalkey, Norman et al., *Studies in the Quality of Life* (Toronto: D. C. Heath and Co., 1972).

David, Edward E., Jr., untitled remarks made at the NAS Meeting of Computer Science and Engineering Board, Washington, DC, 25 June 1971.

Dial, Oliver, "Why There Are No Urban Information Systems Yet", in Alan F. Westin, ed., *Information Technology in a Democracy* (Cambridge: Harvard University Press, 1971).

Duggan, Michael A., "Computers and Individual Access", paper presented to the Workshop on Computers and Individual Access, Institute for the Future, Spring 1973.

Dutton, John M., and Starbuck, William H., *Computer Simulation of Human Behavior* (New York: John Wiley & Sons, 1971).

Farrar, Donald E., "The Coming Reform on Wall Street", *Harvard Business Review* (September/October 1972), pp. 108-117.

Federal Reserve System, Steering Committee on Improving the Payments Mechanism, "Evolution of the Payments Mechanism", *Federal Reserve Bulletin* (December 1972), pp. 1009-1012.

Flood, Merrill, *Commercial Information Processing Network--Prospects and Problems in Perspective* (September 1965).

Fromm, Gary, "Policy Decisions and Economic Models", paper presented to the Workshop on Computer Modeling and Simulation, Institute for the Future, Spring 1973.

Gotlieb, C. G., and Borodin, A., *Social Issues in Computing* (New York: Academic Press, 1973).

Greenberger, Martin, ed., *Computers, Communications, and the Public Interest* (Baltimore: The Johns Hopkins Press, 1971).

Helmer, Olaf, and Helmer, Helen, *Future Opportunities for Foundation Support*, Report R-11, Institute for the Future (1970).

Hoffman, Lance J., ed., *Security and Privacy in Computer Systems* (Los Angeles: Melville Publishing Company, 1973).

Holt, Robert T., "Anticipating the Social Consequences of Technological Change", paper read at the Annual Meeting of the Division of Behavioral Sciences, National Academy of Sciences, 19-20 May 1972.

Information Technology: Some Critical Implications for Decision Makers (New York: The Conference Board, 1972).

Jones, Martin V., *A Technology Assessment Methodology: Project Summary*, The Mitre Corporation (June 1971).

Kemeny, John G., *Man and the Computer* (New York: Charles Scribner's Sons, 1972).

Kiefer, David M., "Technology Assessment", *Chemical & Engineering News*, vol. 48 (1970), pp. 42-56.

Kiviat, Philip J., "Computer Modeling and Simulation", paper presented to the Workshop on Computer Modeling and Simulation, Institute for the Future, Spring 1973.

Kling, Rob, "Towards a Person-Centered Computer Technology", University of Wisconsin (n.d.), mimeographed.

Kotter, Philip, "Corporate Models: Better Marketing Plans", *Harvard Business Review* (July/August 1970).

Lazarsfeld, P., and Henry, N. W., eds., *Readings in Mathematical Social Sciences* (Chicago: Science Research Associates, 1966).

Lee, Robert S., "Social Attitudes and the Computer Revolution" (n.d.), xeroxed.

Leininger, Joseph E., and Gilchrist, Bruce, eds., *Computers, Society, and Law: The Role of Legal Education*, Proceedings of the AFIPS/Stanford Conference on Computers, Society, and Law, 25-27 June 1973.

Library of Congress, Congressional Research Service, Science Policy Division, *Technical Information for Congress*, Report to U.S. Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research, and Development (April 1969; revised April 1971).

Limaye, Dilip R., and Blumberg, Donald F., "Systems for Urban Planning and Management", Decision Science Corporation (n.d.), mimeographed.

Lipis, Allen H., "Electronic Funds Transfer Helps Banks Fight Check Deluge", *Computer Decisions* (November 1972), pp. 18-22.

Marvick, Dwaine, "Public Perceptions of the Impact of Computers on Their Life Styles", The University of California at Los Angeles (n.d.), mimeographed.

Marvick, Dwaine, "The Impact of Computerization in Los Angeles, 1973: Some Sample Survey Differentials in Perceptions and Attitudes", paper presented to the Workshop on Computer Perceptions, Attitudes, and Literacy, Institute for the Future, Spring 1973.

McCracken, Daniel D., "Some Negative Social Side Effects of Computer Technology", paper prepared for the Open University, April 1973.

McPhail, Thomas L., "How the Public Receives the Computer: Some Social-Psychological Dimensions", in Stanley Winkler, ed., *Computer Communications: Impacts and Implications,* Proceedings of First International Conference on Computer Communication, Washington, DC, 24-25 October 1972.

Meadows, Dennis L., "Toward a Science of Social Forecasting", *Proceedings of The National Academy of Sciences,* vol. 69, no. 12 (1972), pp. 3828-3831.

Meadows, Donella H., and Meadows, Dennis L., "A Summary of *Limits to Growth*--Its Critics and Its Challenge", paper presented to the Symposium on Limits to Growth, Yale University, February 1973.

Meier, Richard L., Blakelock, Edwin H., and Hinomoto, Hirohide, "Computers in Behavioral Science", *Behavioral Science,* vol. 9, no. 1 (1964), pp. 67-89.

Nanus, B., Wooton, H., and Borko, H., *The Social Implications of the Use of Computers Across National Boundaries,* (Montvale, NJ: AFIPS Press, 1973).

National Academy of Engineering, Committee on Public Engineering Policy, *A Study of Technology Assessment,* Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969).

National Academy of Sciences, *Technology: Process of Assessment and Choice,* Report to the U.S. Congress, House, Committee on Science and Astronautics (July 1969).

Naylor, Thomas H., and Finger, J. M., "Verification of Computer Simulation Models", *Management Science,* vol. 14, no. 2 (1967), pp. B92-B101.

O'Neill, Hugh V., *A Technology Assessment Methodology: Computer Communications Networks,* vol. 3, MTR-6009, The Mitre Corporation (June 1971).

Parker, Edwin B., "The New Communication Media", in C. Wallia, ed., *Toward Century 21* (New York: Basic Books, 1970).

Petruschell, R. L. et al., *Reducing Costs of Stock Transactions: A Study of Alternative Trade Completion Systems*, vols. 1-3, R-552-ST, The Rand Corporation (December 1970).

Pylyshyn, Zenon W., ed., *Perspectives on the Computer Revolution* (Englewood Cliffs, NJ: Prentice-Hall, 1970).

Raser, John R., *Simulation and Society* (Boston: Allyn and Bacon, 1969).

Reid, Alex, *New Directions in Telecommunications Research,* Report to the Alfred P. Sloan Commission on Cable Communications (June 1971).

Rothman, Stanley, and Mosmann, Charles, *Computers and Society* (Chicago: Science Research Associates, 1972).

Sackman, Harold and Boehm, B., eds., *Planning Community Information Utilities* (Montvale, NJ: AFIPS Press, 1972).

Salancik, J. R., Gordon, Theodore J., and Adams, Neale, *On the Nature of Economic Losses Arising from Computer-Based Systems in the Next Fifteen Years*, Report R-23, Institute for the Future (March 1972).

Schramm, Wilbur et al., *Television in the Lives of our Children* (Stanford, CA: Stanford University Press, 1961).

Schramm, Wilbur, and Lerner, Daniel, eds., *Communication and Change in Developing Countries* (Honolulu: East-West Center Press, 1967).

Selwyn, Lee L., "Information Technology and Individual Access: Some Economic and Regulatory Considerations", paper presented to the Workshop on Computers and Individual Access, Institute for the Future, Spring 1973.

Shubik, Martin, and Brewer, Garry D., *Models, Simulations, and Games--A Survey*, R-1060-ARPA/RC, The Rand Corporation (May 1972).

Shubik, M[artin], Brewer, G[arry D.], and Savage, E., *The Literature of Gaming, Simulation, and Model-Building: Index and Critical Abstracts*, R-620-ARPA, The Rand Corporation (June 1972).

Stone, Philip, "Public Opinion in a Future Democratic Society", in C. Wallia, ed., *Toward Century 21* (New York: Basic Books, 1970).

Taviss, Irene, "Some Thoughts on the Questions for the Conference", paper presented to the Workshop on Computer Perceptions, Attitudes, and Literacy, Institute for the Future, Spring 1973.

Television and Growing Up: The Impact of Televised Violence (Washington, DC: U.S. Government Printing Office, 1972).

Thompson, Frederick B., "The Dynamics of Information", *The Key Reporter*, (Winter 1972/73), pp. 2-5.

Thompson, Frederick B., "Computers and Contextual Change", paper presented to the Workshop on Computers and Individual Access, Institute for the Future, Spring 1973.

Thompson, Gordon B., "Three Characterizations of Communications Revolutions", in Stanley Winkler, ed., *Computer Communications: Impacts and Implications*, Proceedings of First International Conference on Computer Communication, Washington, DC, 24-25 October 1972.

Time Magazine, and American Federation of Information Processing Societies, Inc., *A National Survey of the Public's Attitudes toward Computers* (New York: Time, 1971).

U.S. Congress, House, Committee on Interstate and Foreign Commerce, Subcommittee on Commerce and Finance, *Securities Industry Study* (1972).

U.S. Department of Health, Education and Welfare, Secretary's Advisory Committee on Automated Personal Data Systems, *Records, Computers and the Rights of Citizens*, DHEW Publication No. (OS) 73-94 (July 1973).

Van Horn, Richard L., "Validation of Simulation Results", *Management Science*, vol. 17, no. 5 (1971), pp. 247-258.

Verougstraete, James R., "The Role and Use of Models in the Regional Planning Process", paper presented to the Workshop on Computer Modeling and Simulation, Institute for the Future, Spring 1973.

Weizenbaum, Joseph, "On the Impact of the Computer on Society", *Science*, vol. 176 (May 1972), pp. 609-614.

Welles, Chris, "The Great Paper Fight: Who Will Control the Machinery?", *Institutional Investor* (May 1973), pp. 41-47 and 108-114.

Westin, Alan F., *Privacy and Freedom* (New York: Atheneum Publishers, 1967).

Westin, Alan F., ed., *Information Technology in a Democracy* (Cambridge: Harvard University Press, 1971).

Westin, Alan F., "Information Systems and Political Decision Making", in Irene Taviss, ed., *The Computer Impact* (Englewood Cliffs, NJ: Prentice-Hall, 1970).

Westin, A[lan F.], and Baker, M., *Databanks in a Free Society* (New York: Quadrangle Press, 1972).

Withington, Frederick G., *The Real Computer: Its Influence, Uses, and Effects* (Reading, MA: Addison-Wesley Publishing Co., 1969).